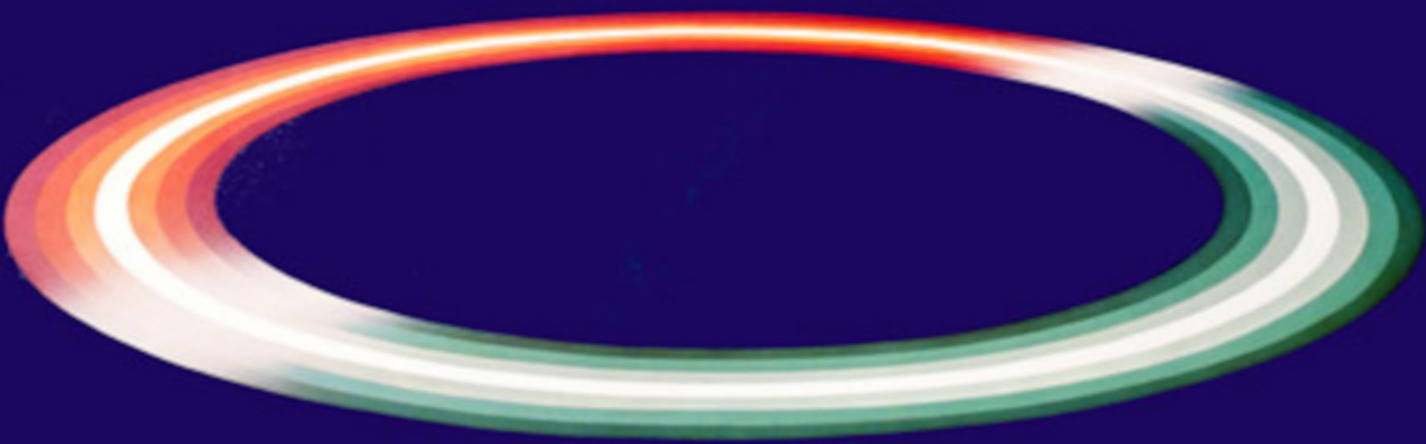
HNPS25

33rd Annual Symposium of the Hellenic Nuclear Physics Society

6 and 7 June 2025

National and Kapodistrian University of Athens

Book of Abstracts



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Program of the 33rd Annual Symposium of the Hellenic Nuclear Physics Society

Friday 06/06/2025	
8:30	**Registration**
9:00	**Welcome Addresses**
Session 1 *Chair: Ch. C. Moustakidis*	
9:30	D. Bonatsos - Triaxial Shapes in Atomic Nuclei
9:50	P. Vasileiou - Exploring Triaxial Deformation in Ground and γ Bands of Even-Even Er Isotopes
10:10	K. E. Karakatsanis - Shape transitions and collective behaviour of Er and Yb isotopes based on relativistic energy density functional theory
10:30	V. Prassa - A Bayesian Network-Based Framework for Predicting Fission Charge Yields
10:50	**Coffee break**
Session 2 *Chair: M. Kokkoris*	
11:10	V. Michalopoulou - Study of the ^{235}U(n,f) reaction in the energy region 1 to 100 eV
11:30	N. Kyritsis - Measurement of the ^{243}Am(n,f) reaction cross-section at the n_TOF facility at CERN
11:50	A. Skouloudaki - Cumulative Yield measurements from ^{235}U(n_{th},f) with the FIPPS detector
12:10	Z. Bari - Cross Section Measurements of Neutron Induced Reactions on Mo Isotopes
12:30	K. Kaperoni - Diamond Detector Development for Neutron Measurements in Harsh Environmental Conditions
Poster session	
12:50	**Light lunch and Poster session**
Session 3 *Chair: D. Bonatsos*	
14:50	Ch. C. Moustakidis - Implications of Kaon Condensation in Dense Nuclear Matter for Recent Light Compact Star Observations
15:10	P. S. Koliogiannis - Nuclear Signatures and Stellar Observables: Bridging Terrestrial Experiments and Neutron Star Structure
15:30	A. Kanakis-Pegios - Investigating isovector properties of finite nuclei through neutron stars
15:50	D. Papoulias - Inelastic neutrino-nucleus scattering using a hybrid nuclear model
16:10	**Coffee break**
Session 4 *Chair: A. Ioannidou*	
16:30	M. Kokkoris - Study of Fundamental Channeling Parameters in a Diamond Crystal Using Deuterons and Combining the EBS and NRA Ion Beam Analysis Techniques
16:50	A. Kanellakopoulos - GAMMA-MRI: A Molecular Imaging modality using anisotropic gamma emission from hyperpolarised nuclei
17:10	G. Kumar - Advances in Radon Based Earthquake Forecasting using Sensor Networking
17:30	Z. Maniati - Studying temporal trends of radionuclides’ and chemical concentrations accumulated at the North Cretan Basin, Greece
17:50	C. Tsabaris - The development of a detection system to inspect suspicious nuclear objects in ships’s hul in the frame of the EU UnderSEC project
18:10	**Short break**
18:15	**HNPS General Assembly and Elections**
20:30	**Conference Dinner**

Saturday 07/06/2025	
Session 5 *Chair: G. Souliotis*	
10:00	P. Koseoglou - Gamma-spectroscopy on the well-deformed ^{178}Yb
10:20	A. Martinou - Future perspectives of the proxy-SU(3) symmetry
10:40	K. Gkatzogias - Multinucleon transfer mechanisms in peripheral collisions of ^{40}Ar + ^{64}Ni at 15 MeV/nucleon
11:00	E. Kontogianni - Multinucleon Transfer in Peripheral Collisions of ^{64}Ni on ^{64}Ni at 25 MeV/nucleon
11:20	O. Fasoula - Multinucleon Transfer Channels in ^{86}Kr + ^{64}Ni peripheral collisions at 15 and 25 MeV/nucleon
11:50	**Coffee break**
Session 6 *Chair: P. Koseoglou*	
12:20	I. Kaissas - Analysis of SMR behavior during normal operation procedures and malfunction events using IAEA's IPWR simulation
12:40	N. G. Nicolis - Progress in Modeling Proton Reactions on Natural Silicon Targets
13:00	M. Peoviti - Preliminary results of (p,γ) and (α,γ) reaction cross-sections on ^{73}Ge relevant to nuclear astrophysics
13:20	E. Mitsi - *In-situ* observation of radiation damage saturation in ion irradiated Fe thin films
13:40	**Closing Remarks for HNPS25**

Poster contributions

Poster session: Friday 06/06/2025 12:50	
P-1	A. Pakou - Abnormal large reaction cross sections for weakly bound nuclei at deep sub-barrier energies
P-2	Michaela Lizardou - Calculations of water activation in fission reactors using Monte Carlo simulations
P-3	A. Tasiopoulou - Analysis of historical events using sediment cores and nuclear methods
P-4	E. Kapsokoli - Soil Radioactivity in urban parks of Piraeus
P-5	S. Zonitsas - Development and Evaluation of a new Proton Irradiation Experimental Set-up for Radiobiological Experiments using Human Cells
P-6	K. Palli - Reaction mechanism for $^{8}B+^{nat}Zr$ at the sub-Coulomb energy of 26.5 MeV
P-7	E. Karpouza - Evaluation of Environmental Radioactivity in Thessaly after Storm Daniel: A Pilot Study
P-8	R. Kourgiantakis - Study of Point Defects due to Ion Irradiation in the CrMnFeCoNi High Entropy Alloy
P-9	E. Travlou - Multinucleon transfer in peripheral collisions of ^{86}Kr on ^{208}Pb at 25 MeV/nucleon
P-10	M. Efstathiou - Ground-state lifetime measurements in Tellurium decay chains: Method and Results
P-11	S. Koulouris - Elastic Scattering of Medium-Mass Heavy-Ions and the Compressibility of the Nuclear Equation of State
P-12	N. Giannakou - Neutron Activation Cross Section Measurement of the (n,2n) Reaction on ^{203}Tl at 14.6 MeV
P-13	K. Topalis - Investigating the nuclear structure of $^{116,118}Te$
P-14	Ch. Giannitsa - Investigation of α-cluster Transfer in Peripheral Collisions of ^{40}Ca (12.3 MeV/nucleon) + ^{27}Al using the MARS Spectrometer at Texas A&M
P-15	S. Karachristos - Study of Deuteron-Induced Reactions in ^{18}O in the Framework of NRA
P-16	A. Violanti - Gamma-ray spectroscopic analysis around the N=104 mid-shell for $^{176,177}Yb$ and ^{182}W nuclei
P-17	A. Karakaxi - Time-of-Flight Neutron Transmission Measurements on ^{nat}Cu at the GELINA Facility
P-18	G. Apostolopoulos - OpenTRIM: an open source Monte-Carlo simulation code for ion transport in materials
P-19	M. Karlatira - Measurement of the $^{234}U(n,f)$ cross-section with Micromegas Detectors
P-20	D. A. Papadopoulos - Investigation of the Yb and W isotopic chains using the confined β-soft rotor model
P-21	K. Konstantinidis - Measurement of the differential cross sections of the $^{24}Mg(p,p'\gamma)$ reaction at three detection angles relevant to the PIGE technique
P-22	Andreas Lymperopoulos - Hauser-Feshbach studies of α-capture reactions in molybdenum isotopes
P-23	N. Pouris - Flux Determination of the 17MeV quasi-monoenergetic Neutron Beam at NCSR “DEMOKRITOS” using the Multiple Foil Activation technique
P-24	E. Bampaloukas - Setup and calibration of in-situ gamma-ray spectrometer for marine applications
P-25	I. Tsormpatzoglou - Characterization of BC501A Liquid Scintillator for Neutron-Gamma Discrimination using the Pulse Shape Analysis Technique

P-26	Danai P. Nikou - Estimation of cross section for proton-induced reactions in stable Yb isotopes at astrophysical energies
P-27	S. K. Roumelioti - Calibration of CZT detector systems for laboratory measurement of marine sediment
P-28	G. Andrianopoulos - Design and operation of an Inertial Electrostatic Confinement Fusion Device (FUSOR)
P-29	A. Kalamara - Simulations for Optimization of Proton Dose Delivery Using the Advanced Markus Chamber
P-30	T. Schizas - Development and construction of an Arduino-based Geiger-Müller detector for radiation monitoring applications

Oral Presentation Abstracts
(in presentation order)

Triaxial Shapes in Atomic Nuclei

Dennis Bonatsos[1], Andriana Martinou[1], S.K. Peroulis[1], D. Petrellis[2], P. Vasileiou[3], T.J. Mertzimekis[3], N. Minkov[4]

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The proxy-SU(3) approximation to the shell model, based on the highest weight irreducible representation (hw irrep) of SU(3) allowed by the Pauli principle and the short-range nature of the nucleon-nucleon interaction, predicts non-vanishing triaxiality all over the nuclear chart, in accordance to the results of recent Monte Carlo shell model calculations challenging the collective model of Bohr and Mottelson. However, highly triaxial shapes are predicted to occur only within certain regions, depicted in Fig. 1, in accordance with empirical data [1]. The importance of the next hw irrep in the few cases in which the hw irrep turns out to be fully symmetric has been pointed out [2].

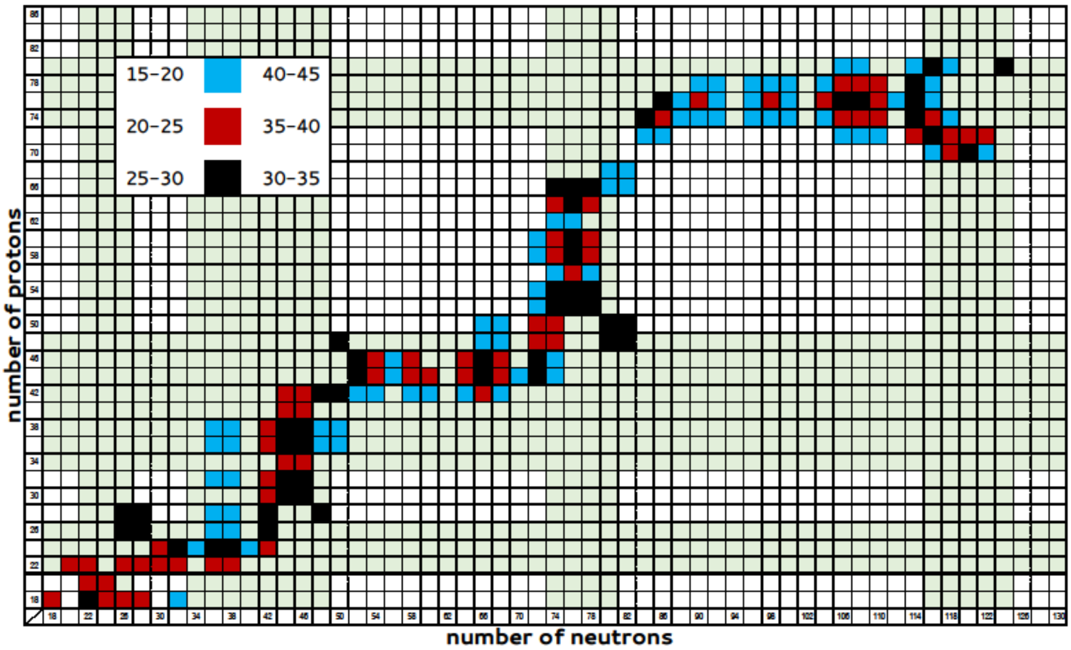

Figure 1: Regions of the nuclear chart in which large triaxiality is predicted by the proxy-SU(3) scheme are shown as green stripes, along with the colour coded values of the collective variable γ.

References

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[2] D. Bonatsos *et al*., Symmetry 16, 1625 (2024)

Exploring Triaxial Deformation in Ground and γ Bands of Even-Even Er Isotopes

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Building on successful applications to the neighboring Hf and W isotopic chains in the rare-earth region [1], this work utilizes a mean-field-derived IBM-1 Hamiltonian that incorporates intrinsic triaxial deformation, determined from fermionic proxy-SU(3) highest weight (h.w.) irreducible representations (irreps), for the study of energy levels and B(E2) transition strengths in the ground and γ bands of even-even Er isotopes, ranging from A = 160 to 180 [2]. The inclusion of intrinsic triaxial deformation, derived from the proxy-SU(3) h.w. irreps, results in significantly improved agreement between theoretical predictions and experimental data, compared to axially symmetric calculations. The results are additionally compared to recent predictions from the triaxial projected shell model (TPSM) [3] and the Monte Carlo Shell Model (MCSM) [4], showing an overall good agreement, further supporting the growing evidence for the widespread presence of triaxial shapes across the nuclear chart [5,6].

References

[1] P. Vasileiou *et al*., Phys. Rev. C **110**, 014313 (2024)
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[3] S. Rouoof *et al*., Eur. Phys. J. A **60**, 40 (2024)
[4] T. Otsuka *et al*., arXiv:2303.11299v8 (2025)
[5] D. Bonatsos *et al*., J. Phys. G.: Nucl. Part. Phys. **52**, 015102 (2025)
[6] D. Bonatsos *et al*., Symmetry **16**, 1625 (2024)

Shape transitions and collective behaviour of Er and Yb isotopes based on relativistic energy density functional theory

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The change in shape of even-even Er and Yb nuclei along the neutron-rich side of their isotopic chains, from N = 82 to N = 110, is examined theoretically. The starting point is a Lorentz-invariant Lagrangian that defines an effective interaction via the exchange of virtual mesons, coupled to the nucleon wavefunction [1,2]. In this framework, nucleons are treated as Dirac spinors. Since the nuclei under investigation are mainly open-shell, an additional finite-range separable pairing force in momentum space is included [3]. By appropriately defining the particle and pairing densities, a covariant energy density functional is constructed, the variation of which leads to the Relativistic Hartree-Bogoliubov (RHB) equations [4]. These equations are solved using the DIRHB code in a triaxial basis, allowing for quadrupole degrees of freedom described by the β_2 and γ deformation parameters [5]. By imposing constraints on these variables during the solution of the RHB equations, potential energy surfaces are obtained for each isotope. The ground-state shape is identified with the global minimum of the surface. Following this procedure, the evolution from spherical to well-deformed axially symmetric shapes is illustrated for both isotopic chains.

In a second step, a five-dimensional collective Hamiltonian incorporating vibrational and rotational degrees of freedom is constructed [6]. Its parameters are determined from the Bogoliubov quasiparticle wavefunctions and occupation numbers obtained from the constrained RHB calculations. Diagonalization of the collective Hamiltonian yields the low-lying collective excitation spectra and *E2* transition probabilities. Examining the ratios of these observables provides important insights into the collective behavior of the isotopes under investigation.

References

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[6] T. Nikšić *et. al.* Phys. Rev. C **79**, 034303 (2009)

A Bayesian Network-Based Framework for Predicting Fission Charge Yields

Vaia Prassa[1]

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Predicting neutron-induced fission charge yields is a long-standing challenge due to the complex, non-equilibrium nature of the fission process and the limited availability of experimental data across a broad range of neutron energies.

This work presents a Bayesian machine learning framework that integrates Gaussian Process Regression (GPR), Bayesian Neural Networks (BNNs), and Mixture Density Network (MDN) outputs to address these challenges. The GPR component augments sparse datasets with synthetic samples and associated uncertainties, while BNN layers capture model uncertainty through variational inference. The MDN output models the multimodal nature of charge yields and accounts for data-driven (aleatoric) uncertainty.

The proposed model accurately reproduces known features of fission yields, such as odd-even staggering and energy dependence, and generalizes well to isotopes not included in the training set. Its probabilistic predictions are consistent with experimental observations and semi-empirical models, offering a robust tool for fission yield modeling.

References

[1] Vaia Prassa, Phys. Rev. C (2025), accepted.

Study of the ^{235}U(n,f) reaction in the energy region 1 to 100 eV*

V. Michalopoulou[1], M. Diakaki[1], N. Kyritsis[1], R. Vlastou[1],
M. Kokkoris[1], Z. Eleme[2], N. Patronis[2] and the n_TOF collaboration[3]

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The ^{235}U(n,f) reaction is widely used as a reference in a wide energy region for the study of neutron induced cross-section measurements and flux monitoring, even though it is considered a standard only at 0.0253 eV, in the energy region between 7.8 and 11 eV and between 150 keV to 200 MeV [1]. Discrepancies have been observed among the latest evaluated libraries; thus, additional measurements can assist in the improvement of the accuracy of the evaluated data and in the extension of the energy region where it is considered a standard. This is the reason why it is still being re-measured with different facilities/techniques [2-4].

In this framework the measurement of the cross-section of the ^{235}U(n,f) reaction was performed at the experimental area EAR-2 of the n_TOF facility at CERN, using the ^{10}B(n,α) standard reaction as reference. For the measurements the gaseous Micromegas detectors were used. The cross-section results were compared with the latest evaluated libraries with the use of the resonance analysis code SAMMY [5], in order to take into account the resolution function of the experimental area EAR-2. The first results from this analysis will be presented here in the energy region 1 to 100 eV.

References

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* This project is carried out within the framework of the National Recovery and Resilience Plan Greece 2.0, funded by the European Union – NextGenerationEU (Implementation body: HFRI).
This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 847594 (ARIEL).

Measurement of the ^{243}Am(n,f) reaction cross-section at the n_TOF facility at CERN*

Nikos Kyritsis[1] , Maria Diakaki[1], Veatriki Michalopoulou[1], Zinovia Eleme[2],
Michael Kokkoris[1], Nikolaos Nikolis[1], Nikolaos Patronis[2], Roza Vlastou[1]
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As part of the development and operation of advanced nuclear reactor systems, accurate data on a wide range of neutron-induced reactions on actinides are crucial. Among the minor actinides produced in a nuclear reactor, ^{243}Am significantly contributes to the long-term radiotoxicity of the waste through production of ^{239}Pu. However, the experimental data available for the ^{243}Am(n,f) reaction present substantial discrepancies in both the thermal and higher neutron energies with very few datasets above 20 MeV. For these reasons, two measurements were performed at the n_TOF facility at CERN, at the experimental areas 1 and 2 (EAR1, EAR2) for the ^{243}Am(n,f) cross-section, with the goal of providing a high-accuracy dataset covering a wide neutron energy range from thermal up to hundreds of MeV. These measurements used the same setup based on the Micromegas detectors and included high purity ^{243}Am and reference samples of high purity ^{235}U, ^{238}U, ^{10}B, provided by the EC-JRC Geel target laboratory.

In this work, a detailed overview of the measurement at EAR1 will be given, with a focus on the high energy range. In order to extend the neutron to the highest neutron energies possible, a special analysis procedure was followed. The analysis together with some first results will be presented.

* This project has received funding from the HORIZON-EURATOM-2023-NRT-01-06 call under grant agreement No 101164596.This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 847594 (ARIEL). This project has received funding from the European Unions Horizon Europe research and innovation programme under grant agreement No 101057511. This project is carried out within the framework of the National Recovery and Resilience Plan Greece 2.0 funded by the European Union – NextGenerationEU (Implementation body: HFRI)

Cumulative Yield measurements from $^{235}U(n_{th},f)$ with the FIPPS detector

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Accurate neutron induced fission yield data are crucial for reactor physics, safeguards, and waste management. Current discrepancies between nuclear databases highlight the need for improved precision for several isotopes, even for the most commonly used ones. This work reports high-precision measurements of the cumulative yield of key isotopes from $^{235}\mathrm{U}(\mathrm{n_{th}}, \mathrm{f})$ reactions using the FIPPS (FIssion Product Prompt γ-ray Spectrometer) [1] at ILL [2], representing the facility's first dedicated fission yield campaign at its newly position. In this work, advanced spectroscopic techniques were employed to reduce nuclear data uncertainties, while evaluating FIPPS' capabilities for fission yield measurements.

During the experiment, a pre-irradiated ^{235}U target was placed in high neutron flux, and the emitted γ-rays were detected with an array of 16 HPGe Clover detectors, each having 4 Ge crystals. Each Clover was coupled with an anti-Compton setup. The experiment consisted of two phases: 7 days of irradiation with a thermal neutron flux of about $5.10^7 n/s/cm^2$ and 23 days of decay. A complex data acquisition system of the delayed γ-rays with remote monitoring ensured measurement stability. The FIPPS setup, whose unique capabilities include multi-parameter data acquisition of the 64 detectors, enables detailed reconstruction of each stage of the fission process, from irradiation to decay. Our analysis framework incorporated Bateman equations for decay-chain modeling and yield transitions, enhanced by machine learning techniques for spectral analysis and γ-emission simulations. Systematic uncertainties were evaluated, particularly in detector efficiency calibration, dead-time effects, and prior irradiation corrections, with special attention to fission product ratios under varying flux conditions.

The Cumulative Yield values for multiple important isotopes were finally determined with small uncertainties, showing good agreement with established libraries. The results were specifically benchmarked against the new JEFF4.0 [3] library release, which was one of this study's key objectives. This study establishes new benchmarks for fission yield measurements and demonstrates the power of combining high precision γ-spectroscopy, with advanced computational methods. The developed methodology provides a robust basis for future fission product studies and nuclear data refinement, particularly for both long- and short-lived isotopes, important in nuclear applications.

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Cross Section Measurements of Neutron Induced Reactions on Mo Isotopes

Z. Bari[1], V. Michalopoulou[1], R. Vlastou[1], M. Diakaki[1], M. Kokkoris[1], M. Axiotis[2], A. Lagoyannis[2], N. Nicolis[3], S.A. Kopanos[1], N. Giannakou[1], N. Pouris[1]

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The study of neutron-induced reaction cross sections for Molybdenum (Mo) isotopes is essential for both astrophysical modeling and various applications in the nuclear industry-particularly in ensuring reactor safety-as well as in nuclear medicine, where Mo is used to produce ^{99m}Tc, a widely used diagnostic radioisotope. To enhance the accuracy of available data-currently limited by considerable uncertainties-neutron capture cross section measurements were conducted for the stable isotopes ^{94}Mo, and ^{96}Mo. Additionally, natural Molybdenum targets were irradiated too. These measurements utilized neutron beams generated via the ^{3}H(d,n)^{4}He reaction at the 5.5 MeV Tandem Van de Graaff accelerator facility of NCSR Demokritos, with energies exceeding 14 MeV, employing the activation technique.

Enriched Molybdenum metallic foils, supplied by the CERN n_TOF collaboration, were used in the experiment. These comprised three material batches containing approximately 98.9% ^{94}Mo and 95.7% ^{96}Mo. To determine the neutron flux at the target position, aluminum (Al) and gold (Au) reference samples were positioned at the front and back of the Mo discs. Continuous irradiations were performed, and the mean total neutron fluence was monitored using a BF_3 detector throughout the process.

Following each irradiation, the activities of both the Mo targets and reference foils were measured offline with HPGe detectors. The activation technique enabled precise measurements of the cross sections for the reactions ^{94}Mo(n,2n)^{93m}Mo, ^{96}Mo(n,p) ^{96}Nb, ^{100}Mo(n,2n)^{99}Mo and ^{100}Mo(n,a)^{97}Zr. The use of isotopically enriched targets effectively eliminated interference from neighboring isotope reactions producing the same residual nuclei.

Diamond Detector Development for Neutron Measurements in Harsh Environmental Conditions*

K. Kaperoni[1], M. Diakaki[1], M. Bacak[3], C. Weiss[3,4], E. Griesmayer[3,4], M. Kokkoris[1] , I.Kopsalis[1], J.Melbinger[3,4]
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Diamond detectors play a crucial role in many radiation applications [1]. Their exceptional properties such as high energy resolution, high thermal conductivity and resistance to radiation make them highly suitable for use in harsh environmental conditions. In recent years, significant progress has been made in the use of diamond detectors for neutron detection across a broad energy spectrum.

This work takes advantage of the mixed field white neutron beam at the NEAR station of the n_TOF facility at CERN. Due to the proximity of the NEAR station to the Pb spallation target (approximately 2.5 m), a high instantaneous neutron flux is produced (~10^{10}/cm^2 neutrons for a proton pulse), which makes the NEAR station a difficult environment in terms of radiation. Consequently, up to now only multiple foil activation techniques have been implemented for the neutron flux characterization [2]. The intense radiation and the high neutron flux at the NEAR station, provide an excellent opportunity to evaluate the ability of the diamond detector to handle high counting rates, to detect clear and distinct neutron signals and eventually evaluate the neutron flux. It is also an ideal setting to assess the radiation-induced damage on the sensor and monitor its degradation. In this work, an experimental campaign was carried out using a 50 μm diamond detector at the NEAR station, during which neutron flux measurements were recorded and the detector's degradation was systematically monitored. The preliminary results of this campaign will be presented and discussed.

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Implications of Kaon Condensation in Dense Nuclear Matter for Recent Light Compact Star Observations*

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Recent measurements of the compact star XTE J1814-338, with a mass of $\mathrm{M} = 1.2^{+0.05}_{-0.05}\,\mathrm{M}_\odot$ and a radius of $\mathrm{R} = 7^{+0.4}_{-0.4}$ km, alongside those of HESS J1731-347, which has a mass of $\mathrm{M} = 0.77^{+0.20}_{-0.17}\,\mathrm{M}_\odot$ and a radius of $\mathrm{R} = 10.4^{+0.86}_{-0.78}$ km, provide compelling evidence for the potential existence of exotic matter in neutron star cores. These observations offer important insights into the equation of state of dense nuclear matter. In this study, we explore the presence of negatively charged kaons and neutral anti-kaons (K^- and $\overline{\mathrm{K}}^0$) within neutron stars using a Relativistic Mean Field (RMF) model with first order kaon condensate and the Momentum-Dependent Interaction model complemented by chiral effective theory. To our knowledge, this is the first alternative approach aiming to simultaneously explain the observed properties of both XTE J1814-338 and HESS J1731-347 by invoking kaon condensation in dense matter. Furthermore, we compare our model with recent data from the pulsars PSR J0437-4715 and PSR J1231-1411, and argue that a two-branch scenario, each representing a distinct form of nuclear matter, may be necessary to account for the diverse range of compact astrophysical objects.

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Nuclear Signatures and Stellar Observables: Bridging Terrestrial Experiments and Neutron Star Structure*

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Insights into the properties of dense, neutron-rich matter emerge from the interplay between nuclear experiments and astrophysical observations. Measurements of parity-violating electron scattering on ^{48}Ca (CREX) and ^{208}Pb (PREX-2), together with electric dipole polarizability data, offer stringent probes of isovector dynamics in nuclei. In this study, a set of relativistic energy density functionals is employed to investigate how these nuclear signatures correlate with neutron star observables, such as stellar radii and tidal deformabilities. By confronting the theoretical predictions with data from both terrestrial experiments and multimessenger observations—including the gravitational wave event GW170817—constraints are derived on the symmetry energy and the high-density behavior of the equation of state. The analysis highlights the influence of including the fourth-order term in the isospin-asymmetry expansion of the energy density on neutron star radius and tidal deformability predictions. At the same time, discrepancies between constraints from CREX and PREX-2 underscore the need for improved experimental precision and additional astrophysical input to refine our understanding of dense matter.

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Investigating isovector properties of finite nuclei through neutron stars

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The role of the nuclear symmetry energy in dense nuclear matter has long been pointed out, especially in the structure of finite nuclei as well as neutron stars. In the high-density region, the uncertainty on its value and experimental data pose the need to examine the behavior of the symmetry energy through neutron star observations. The recent advances in nuclear astrophysics in the last years, mainly via the gravitational waves detections of merging binary neutron star systems, provide important information on both radius and tidal deformability of neutron stars; two quantities which are related to the behavior of symmetry energy. In the present study, the main goal is the extraction of constraints by using recent observations, i.e. from violent phenomena in the universe to shed light on the microscopic properties of nuclear symmetry energy. Our approach uses a parametrization of the equation of state, describing both symmetric and asymmetric nuclear matter through a parameter that consists of the incompressibility and the slope. In a practical point of view, we treat this parameter as a regulator of the stiffness of the equation of state, affecting both the properties of finite nuclei and neutron stars. The corresponding constraints on this parameter lead to constraining neutron star properties. For this purpose, we take into consideration the recent experiments of PREX-2 and the most accurately measured observational data of the GW170817 event.

Inelastic neutrino-nucleus scattering using a hybrid nuclear model

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We present nuclear structure calculations adopting a novel hybrid nuclear model, combining the nuclear shell model and the microscopic quasiparticle-phonon model [1]. The predictivity of the hybrid model is tested by computing inelastic neutral-current neutrino-nucleus scattering cross sections off the stable thallium isotopes, taking also into account the effect of nuclear recoil energy. The model is applied assuming neutrinos emerging from: i) the sun, ii) pion-decay at rest and iii) the diffuse supernova neutrino background. Regarding solar neutrino rates, the new results are compared with previously reported results based solely on nuclear shell model calculations [2], demonstrating the improved accuracy of the adopted hybrid model at higher neutrino energies.

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Study of Fundamental Channeling Parameters in a Diamond Crystal Using Deuterons and Combining the EBS and NRA Ion Beam Analysis Techniques

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Due to their distinctive properties, diamond crystals are commonly utilized in numerous scientific and technical applications. Moreover, diamond has emerged as an innovative material for the creation of high-resolution, rapid, and radiation-resistant detectors. Consequently, it is imperative to investigate the fundamental channeling properties of diamond in its single crystalline state using diverse light beam ions. Furthermore, the Elastic Backscattering Spectroscopy (EBS) technique and the Nuclear Reaction Analysis (NRA) one utilizing deuterons have not been previously applied to determine the channeling stopping power ratio and the associated dechanneling function parameters.

In this study, deuterons within the energy range of 1.2 to 1.5 MeV were utilized with a 100 keV energy increment. This constitutes the first attempt to ascertain the fundamental parameters for the channeling process in the backscattering geometry by concurrently utilizing the $^{12}C(d,p_0)$ reaction (NRA) and deuteron elastic scattering within the non-Rutherford energy regime (EBS). However, the study is hindered by supplementary effects evident in the elastic backscattering spectra, resulting from the extraneous contribution of the $^{12}C(d,n)^{13}N$ reaction. Theoretical spectra with random orientation were simulated using SIMNRA and compared to the observed spectra. The fundamental parameters were ascertained utilizing the experimental channeling spectra and a Fortran-based program, in conjunction with the precise MINUIT minimization algorithms created at CERN. The results derived from the spectral analysis will be presented, accompanied by a comparison with previously reported findings for diamond utilizing elastically scattered protons in the literature [1].

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GAMMA-MRI: A Molecular Imaging modality using anisotropic gamma emission from hyperpolarised nuclei*

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The GAMMA-MRI project is a Horizon 2020 funded project that aims to bring innovation in clinical molecular imaging. With GAMMA-MRI we promise to overcome the problem of limited tissue signalling, that dictates that a minimum of 10^{24} atoms in an organ are required to record an MRI signal. To mitigate the low signal detection sensitivity of MRI, a radioactive γ-emitter isotope with a γ energy close to the one of ^{99m}Tc (SPECT isotope) is used.

GAMMA-MRI is based on the detection of the asymmetric γ-emission of long-lived isomers of radioactive noble gas nuclei with spin I>1/2. To observe any γ-ray asymmetry in space the radioactive nuclei need to be polarised. Here, we use Spin Exchange Optical Pumping (SEOP), a hyperpolarisation technique being utilised in clinical settings for lung perfusion studies [1]. The long-lived isomers that were produced via Neutron Activation (in ILL, Grenoble, France and MARIA reactor, Warsaw, Poland) and tested during the current project were ^{129m}Xe ($T_{1/2}$=8.88 d, E_γ=196.6 keV) and ^{131m}Xe ($T_{1/2}$=11.84 d, E_γ=163.9 keV) [2]. Once the mXe are produced, they are inserted into a SEOP borosilicate glass cell, where natural Rb is present. A mixture of Rb, mXe, N_2 and occasionally He is added in the SEOP cell. The SEOP glass cell is then placed in the centre of a custom-made oven and at the geometrical centre of a 5-50 mT B_0 magnetic field created by a set of Helmholtz coils of the SEOP Hyperpolarisation (HP) system. Oven heating at T>40 ^{o}C creates Rb vapours and laser irradiation (QCP diode laser, 795 nm) initiates the Optical Pumping process that creates atomic polarization of Rb. Spin Exchange between the Rb atoms and the mXe nuclear spins leads to hyperpolarised (HP) mXe. During the radioactive decay of HP, mXe γ photons are emitted anisotropically in space following a preferential emission perpendicular to the B_0 axis. Numerous CsI(Tl) Gamma detectors (2-8) surrounding the glass cell can record the gamma count asymmetry between the transversal and the longitudinal planes.

We will present the physical principles of the GAMMA-MRI technique, the systems developed during our project, and the best NMR and MRI results acquired so far using the GAMMA-MRI prototype device with radioactive mXe.

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Advances in Radon Based Earthquake Forecasting using Sensor Networking*

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For decades, scientists have searched for reliable early warning signs of earthquakes[1]. One promising clue lies in radon (Rn), a gas released when uranium decays in the Earth's crust. Studies have shown that radon levels can show variations before an earthquake [2], likely due to stress deep underground causing cracks that allow radon to escape. Carrier gases like CO_2 and CH_4 help transport radon to the surface, affecting its concentration in groundwater [3]. Unlike air and soil measurements, which are influenced by weather and other external factors, groundwater monitoring offers a more stable and sensitive way to track these changes [2, 4].
The *ArtEmis* Euratom project is advancing earthquake research by deploying a dense network of 50–100 radon sensors across earthquake-prone regions in Greece, Italy, and Switzerland. These sensors use scintillators integrated with Silicon Photomultipliers [5], making radon detection both simple and efficient. In addition to radon levels, they continuously monitor environmental factors such as pressure, conductivity, and temperature [6]. Our latest prototypes are not only more sensitive but also smarter and easier to deploy, with enhanced communication capabilities. To process the vast amounts of data collected, *ArtEmis* is integrating AI tools to identify patterns and correlate radon fluctuations with seismic activity [7]. The first round of prototype installations has already delivered promising results. Currently, we are improving and expanding our sensor network with the aim of providing new insights that could one day contribute to a trustable and effective earthquake forecasting.

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Studying temporal trends of radionuclides' and chemical concentrations accumulated at the North Cretan Basin, Greece*

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The deep ocean basins, functioning as semi-closed systems, exhibit limited interaction with both the atmosphere and the benthic circulation of oceanic water masses. Consequently, they serve as ideal natural laboratories for investigating the cycles of key physicochemical parameters and tracers that are essential for understanding environmental processes and ecosystem dynamics. Marine sediments, in particular, offer an excellent medium for tracing the historical evolution of various parameters, including pollutant deposition. In this work a sediment core was retrieved from the North Cretan Basin at a depth of 1500 m using a box corer sampler. The study aimed to determine the sedimentation rate, assess radioactivity levels and identify potential geochemical markers within the core. Radionuclide activity concentrations were measured at the Marine Environmental Laboratory of HCMR using gamma spectroscopy with a High-Purity Germanium (HPGe) detector. Sedimentation rates were estimated through radio-dating methods based on both the $^{210}Pb_{ex}$ and ^{137}Cs radionuclides. Due to the low sedimentation rate in the area, the cesium peaks corresponding to the Chernobyl accident and earlier nuclear tests overlapped, making them difficult to distinguish. Nevertheless, the sediment core preserved a significant historical records spanning the last five centuries. The ^{210}Pb dating model indicated a sedimentation rate of (0.037 ± 0.007) $cm \cdot yr^{-1}$. A distinct "black" layer is attributed to volcanic ash produces probably from the Kolumbo eruption near Santorini, which occurred approximately 300 years ago (clearly detected at a depth of about 11 cm). Additionally, the vertical profiles of organic and inorganic carbon concentrations further supported the identification of the tephra layer within the sediment core. Further investigations is required to interpret sediment dynamics of the deep basin due to land-sea and atmospheric interactions.

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The development of a detection system to inspect suspicious nuclear objects in ships's hul in the frame of the EU UnderSEC project

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In the frame of the EU UnderSEC project, a new detection system (sensor and vehicle) was developed and applied for identifying radioactive sources in ships. The development of the detection system is based on existing architectures developed the last 20 years in the Marine Environmental Radioactivity Laboratory of HCMR [1, 2, 3]. The underwater sensor consists of a scintillator crystal together appropriate digital electronics to acquire the gamma-ray intensity in the environment and save the gamma-ray spectra in a non-volatile memory. The crystal, the electronic modules and the processing unit are housed in a special enclosure for underwater use and stand-alone operation. The underwater sensor was integrated together with an underwater battery under the marine drone. The detection system (sensor and drone) is tested in a controlled environment (water tank) at HCMR premises using as simulant natural radionuclides (e.g. ^{40}K). A second experiment was also performed using as simulant a sealed ^{137}Cs point source in the same lab-based tank selecting different distances between the sensor and the radioactivity source. The new system exhibits high performance in terms of buoyancy, maneuverability as well as electronics stability. The validation of the results are promising in terms of inspecting suspicious objects in and under the hulls of the ships. The new system will be applied for nuclear security needs in port authorities.

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Gamma-spectroscopy on the well-deformed ^{178}Yb*

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The Yb isotopes near the N=104 mid-shell region show a transition from spherical to well-deformed, rigid-rotor-like, structures. The ^{178}Yb isotope (the most neutron-rich Yb isotope with measured excited states) shows signs of high deformation. An experiment was conducted in the 10 MV FN Tandem accelerator of the Institut für Kernphysik at the University of Cologne to study ^{178}Yb and the deformation evolution in the isotopic chain. The γ-spectroscopy findings will be presented in this contribution. The measured γ-rays energies from the ground-band states of ^{178}Yb deviate from the literature values. The new energies set ^{178}Yb as the most rigid-rotor-like isotope in its isotopic chain. Additionally, the excitation function of the two-neutron transfer reaction ^{176}Yb(^{18}O,^{16}O)^{178}Yb which was measured across a range of beam energies, both below and above the Coulomb barrier, will be discussed.

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Future perspectives of the proxy-SU(3) symmetry

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The proxy-SU(3) symmetry, which has initiated in 2017 [1], has extended the Shell Model SU(3) symmetry in medium mass and heavy nuclei. Since then, the nuclear deformation [2,3] along with the nuclear shape coexistence [4] have been predicted all across the nuclear chart. Some of the future perspectives of the proxy-SU(3) predictions will be discussed: the octupole magic numbers [5] and the B(E3) predictions, the B(E2) predictions without scaling factors or effective charges and the nuclear reactions cross sections.

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Multinucleon transfer mechanisms in peripheral collisions of ^{40}Ar + ^{64}Ni at 15 MeV/nucleon

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We report high-resolution studies of reaction products from the interaction of a 15 MeV/nucleon ^{40}Ar beam with a ^{64}Ni target. The experimental data were obtained with the MARS spectrometer at the Cyclotron Institute of Texas A&M University in previous work of our group [1]. Computational calculations have been performed with the Deep-Inelastic Transfer (DIT) [2] and the Constrained Molecular Dynamics (CoMD) models [3], both coupled to the statistical decay code GEMINI [4]. The resulting mass, angular and momentum distributions have been compared with the corresponding experimental distributions. Both models describe the general trends of the data in a satisfactory way. We plan to further explore the role of specific model parameters (nuclear potentials in DIT, nuclear compressibilities in CoMD) to provide further insight into the mechanisms of nuclear reactions below the Fermi energy (10-35 MeV).

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Multinucleon Transfer in Peripheral Collisions of ^{64}Ni on ^{64}Ni at 25 MeV/nucleon

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We study the yields, the momentum distributions and the angular distributions of projectile-like fragments from peripheral collisions of ^{64}Ni (25 MeV/nucleon) on ^{64}Ni. The experimental data were obtained in previous works with the BigSol separator system at the Cyclotron Institute of Texas A&M University. Projectile fragments were collected and analyzed at forward angles (1.5^o-3^o). The production cross sections, the momentum distributions (p/A) and the angular distributions of the fragments were systematically studied and compared with the Deep-Inelastic Transfer (DIT) model and the Constrained Molecular Dynamics (CoMD) model followed by the deexcitation model GEMINI. Both models appear to describe the data rather adequately, but possible improvements are necessary. Special attention is given in the possibility to produce neutron-rich rare isotopes of elements at the beginning of the astrophysical r-process. Moreover, efforts similar to current work are ongoing to shed light to the reaction mechanisms of peripheral collisions at this energy (25 MeV/nucleon).

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Multinucleon Transfer Channels in $^{86}Kr + ^{64}Ni$ peripheral collisions at 15 and 25 MeV/nucleon

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The production of exotic nuclei is a topic of great interest in the nuclear community. One of the means to access these nuclei is through multinucleon transfer (MNT) and deep inelastic transfer reactions near the Fermi energy (15-35 MeV/nucleon) [1,2].

In this work, we present part of our detailed study of multinucleon transfer reaction mechanisms on peripheral collisions between an ^{86}Kr beam at 15 and 25 MeV/nucleon with a ^{64}Ni target. The study of the momentum distributions of reaction channels that produce various projectile-like fragments from neutron rich to neutron deficient is essential for our studies. The experimental data of these reactions were obtained with Momentum Achromat Recoil Separator (MARS) at Texas A&M University in previous works of our group [3,4]. The 15 MeV/nucleon $^{86}Kr + ^{64}Ni$ were collected at an angle of 4° and the 25 MeV/nucleon $^{86}Kr + ^{64}Ni$ were collected at 0° relative to the optical axis of the spectrometer.

In this work, two models were employed to simulate the dynamical part of the reactions. The phenomenological Deep Inelastic Transfer model (DIT) [5] and the microscopic Constrained Molecular Dynamics model (CoMD) [6]. Both were followed by the GEMINI model [7] for the deexcitation of the initial excited projectile-like fragments.

Both models appear to describe the overall features of the data fairly well at 25 MeV/nucleon whereas they show larger deviations at 15 MeV/nucleon. This can be attributed to the presence of direct transfer and cluster transfer mechanisms in addition to the main mechanism of independent nucleon exchange at 15 MeV/nucleon.

In tandem with our recent work [8-9], we envision that the study of the momentum distributions will prove to be a useful tool in the elucidation of the reaction mechanisms that dominate the Fermi Energy regime.

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Analysis of SMR behavior during normal operation procedures and malfunction events using IAEA's IPWR simulation

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Small modular reactors are nuclear reactors with a maximum power capacity of 300 MW(e) according to IAEA's classification of nuclear reactors [1]. Advertised for their short installation time, comparing with Nuclear Power Plants, and their negligible CO_2 emissions, SMRs can act as a complementary power source to a power grid based on renewable and carbon – free energy production. Due to their low power and their passive safety systems, in case of operation failure, damage is minimized without human intervention. The shut down systems rely on physical phenomena to operate and lower the risk of radioactivity release. For example, the passive decay heat removal system (PDHR) relies on natural circulation of the coolant, while the gravity driven water injection system (GIS) and the control rod actuation in case of SCRAM event rely on gravity.

This study exploits IAEA's IPWR simulation to observe the behavior of an SMR during different normal operation procedures such as: Changes in load demand in different operation modes (turbine or reactor leading), hot or cold shutdown and reactor startup. Also, malfunction events are studied. During these events different safety systems, such as the PDHR and GIS, but also other safety systems like the automatic depressurization system (ADS) and the pressure injection system (PIS), are activated to prevent further damage. The malfunction events studied are turbine malfunction, loss of feedwater flow, steam line break inside containment building and station blackout. In these scenarios, phenomena like (a) Xe build-up, (b) decay heat from fission byproducts after shutdown and (c) how coolant temperature affects criticality are analysed in the present study. For example, in the loss of feedwater flow malfunction scenario, Xe reactivity reaches its most negative value of -3444 pcm after approximately 7 hours, while the coolant average temperature stabilizes at 155.5 ^{o}C after 16 hours. Such results can be useful for the appropriate selection of materials and components of SMRs. Also, the analysis of blackout malfunctions concludes that for the SMR to cooldown properly, the ADS valves can be regulated in "fail-open" mode to prevent further damages.

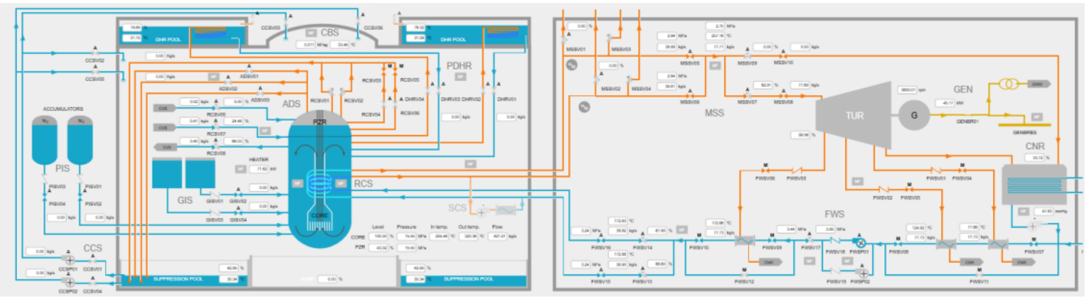

Figure 1: IAEA's IPWR simulator systems page.

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Progress in Modeling Proton Reactions on Natural Silicon Targets

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The study of nuclear reactions involving protons and natural silicon is essential for understanding radiation damage in semiconductor devices. In this work, we analyze the excitation functions of ^{28}Mg, ^{26}Al, ^{24}Na, ^{22}Na, ^{18}F, ^{10}Be and ^{7}Be produced in $p + {}^{nat}Si$ interactions at beam energies ranging from 20 to 150 MeV. Experimental cross-section data were obtained from the EXFOR library [1] and compared with predictions from **Version 2.0** of the TALYS nuclear reaction code [2].

Six level density models were evaluated, with two of them demonstrating superior accuracy in describing excitation functions leading to heavy residue formation. As anticipated, the production of ^{10}Be and ^{7}Be was found to be negligible or absent, since the employed version of TALYS does not account for heavy fragment emission.

Additionally, preliminary calculations were performed to describe these reactions using a simplified approach using an intranuclear cascade (INC) followed by statistical binary decay model. For this purpose, we employed the INC code ISABEL [3,4] coupled with the sequential binary decay code MECO [4]. We present preliminary results, discuss the low-energy validity and limitations of this approach, and suggest possible extensions for improved modeling.

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Preliminary results of (p,γ) and (α,γ) reaction cross-sections on ^{73}Ge relevant to nuclear astrophysics

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The production of most elements heavier than iron occurs in stellar environments via the s- and r-processes. A third, less common mechanism, the "p-process", is responsible for the production of a limited number of proton-rich isotopes known as “p-nuclei”. Accurately reproducing the solar system abundances of p-nuclei remains a significant challenge in astrophysics. The theoretical model predictions require solving an extensive reaction network, encompassing over 20000 reactions and approximately 2000 nuclei with mass numbers between 70 and 190. In addition to stellar conditions, reaction cross-section values are essential for the abundance calculations. However, experimentally determining each cross-section is unfeasible due to the vast number of reactions and the involvement of unstable isotopes [1]. Therefore, calculations based on the Hauser-Feshbach (HF) theory play a crucial role in estimating these cross-sections. The reliability of theoretical calculations depends heavily on the model parameters used, which can be refined through experimental data. Measurements involving p-process-related reactions are the key in constraining HF model parameters.

This study presents preliminary cross-section results for the ^{73}Ge(p,γ)^{74}As and ^{73}Ge(α,γ)^{77}Se reactions at energies within the respective Gamow window[2]. The experiments were conducted at the RUBION Dynamitron Tandem Laboratory, Ruhr-University Bochum, Germany, using the 4π γ-summing technique with a high-efficiency 12×12” NaI(Tl) scintillator detector.

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In-situ observation of radiation damage saturation in ion irradiated Fe thin films

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Materials in future nuclear energy systems such as fusion and generation IV fission reactors will operate under extreme conditions, including intense neutron irradiation and high temperatures. Assessing and optimizing material performance under such demanding environments is essential, necessitating the development of reliable, predictive modeling frameworks. As a result, there has been renewed scientific interest on radiation damage mechanisms, particularly under high-dose conditions that more accurately reflect real-world scenarios.

Within this renewed interest, the present work investigates a long-standing hypothesis suggesting that the accumulation of radiation damage gradually slows down and probably saturates with increasing dose. While recent experimental and simulation studies support this idea, experimental evidence has so far been largely indirect.

In this work, we investigate in-situ the evolution of heavy ion induced damage in iron thin films, capturing for the first time the transition from linear defect accumulation at low doses ($\sim10^{-5}$ displacements per atom, dpa) to apparent saturation near 1 dpa. Irradiations are performed at cryogenic temperatures and radiation damage accumulation is monitored by changes to the electrical resistivity – a highly sensitive, direct measure of defect concentration. Oxygen and copper ion beams from the 5.5 MV Tandem accelerator at NCSR "Demokritos" were utilized to achieve damage levels up to 1 dpa, minimizing ion implantation within the Fe layer. The results are in good qualitative agreement with recent theoretical predictions.

Poster Presentation Abstracts
(by poster number)

Abnormal large reaction cross sections for weakly bound nuclei at deep sub-barrier energies

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We review previous total reaction cross sections of weakly bound projectiles [1-3] at deep sub-barrier energies versus the reaction cross section of the mostly tightly bound nucleus ^{4}He on lead [5-6]. Abnormal large reaction cross sections are traced at deep sub-barrier energies for both ^{8}B and ^{7}Be with ratio's million higher than relevant results at barrier energies. The results will be discussed.

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Calculations of water activation in fission reactors using Monte Carlo simulations

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Water has a crucial role in nuclear facilities, particularly in fission reactors, where it serves as a key component of the cooling system. As the water passes through the reactor core, it becomes activated by neutrons, producing short lived radioactive isotopes such as O-19, N-17 and N-16 with half-lives of 26.47 s, 4.17 s and 7.1 s, respectively. The high-energy photons emitted from these isotopes can increase radiation exposure to the reactor personnel and contribute to degradation of electronic components [1].

In the present work, water activation in a by-pass circuit of a fission reactor cooling system was studied using Monte Carlo simulations. Specifically, the MCNP [2] and PENELOPE [3] codes were employed to model the response of a gamma-spectrometry system used to detect photons emitted from the activated coolant water. Detailed models of the experimental set-up were developed, including the High Purity Germanium (HPGe) detector, its shielding, a lead collimator and the water filled cooling pipe. Full Energy Peak Efficiency (FEPE) was estimated over a wide range of photon energies, from 25 keV to 7.5 MeV, using the pulse height tally available in both Monte Carlo codes. The results from MCNP and PENELOPE codes showed an excellent agreement, with discrepancies within 2%. Predicted FEPE values will also be compared against experimental results.

The developed model of the HPGe-based gamma spectrometry system provides a robust tool for the radiological characterization of coolant water in fission reactors. Furthermore, it holds potential for application in other nuclear systems, such as the cooling circuits of fusion reactor components (i.e. the breeding blanket cooling systems).

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Analysis of historical events using sediment cores and nuclear methods

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In this work, a 44 cm sediment core was collected from the Athos deep basin at a depth of 1180 meters, in order to assess the natural and anthropogenic radioactivity using a high-purity germanium detector. To achieve better depth resolution in the upper layers, the core was sampled at fine intervals of 0.5 cm within the 0-15cm depth range. A total of 50 samples were collected and measured. The activity concentration was determined for the radionuclides ^{214}Pb, ^{210}Pb and ^{214}Bi, ^{228}Ac, ^{208}Tl and ^{212}Pb, the natural radioisotope ^{40}K and the artificial radionuclide ^{137}Cs, using the gamma spectroscopy method. The sedimentation rate was calculated for the Chernobyl accident (1986) and the nuclear tests (1963) by applying radio-dating models, utilizing both the $^{210}Pb_{ex}$ method and the ^{137}Cs method, in order to validate the results. According to the $^{210}Pb_{ex}$ radiometric-dating model, the sedimentation rate in the 0-8.25 cm range is approximately$(0.10 \pm 0.01)\, cm/y$, while using the ^{137}Cs method, the sedimentation rate is $(0.081 \pm 0.002)\, cm/y$ from the sampling period till the Chernobyl accident and $(0.127 \pm 0.001)\, cm/y$ for the nuclear tests, respectively. The results suggest a relatively high sedimentation rate, with approximately 1 cm of sediment accumulating every 10 years. It appears that the sedimentation rate in this deep basin is influenced by multiple factors, due to land-sea interaction processes as well as due to atmospheric fallout.

Soil Radioactivity in urban parks of Piraeus

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In the present study, the levels of natural and artificial radioactivity in twenty (20) urban parks in Piraeus and the surrounding areas have been assessed**.** The study is an extension of the radioactivity survey conducted by Gelatsoras et al. in 2023 in urban parks in the wider Attica region, now shifting the focus on the industrial area around the largest Greek port, which is major touristic and transportation hub. High-resolution γ-ray spectroscopy was carried out in properly prepared samples at the recently upgraded Advanced Laboratory for Environmental Radiation Technology (ALERT) at National and Kapodistrian University of Athens. The measured specific activities of NORM (^{40}K, U- and Th-series), as well as of ^{137}Cs, the major Chernobyl fallout tracer, are reported. A recently developed GIS dashboard provides interactive maps of the surveyed area allowing for easy access to the radiological status of Piraeus urban parks. Even though the results show a trend in agreement with the average background levels in Greece, a few exceptions suggest that further work is required.

Development and Evaluation of a new Proton Irradiation Experimental Set-up for Radiobiological Experiments using Human Cells

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The objective of this study was the design, development and evaluation of a proton irradiation experimental setup for human cells and for research purposes. The impetus of this research originated from the high importance of proton therapy that has significantly advanced in recent years, worldwide, since protons, due to their physical characteristics, have proven to be very efficient in radiation therapy. The proton irradiation setup will be installed and used at the Tandem accelerator, of the Institute of Nuclear and Particle Physics, NCSR "Demokritos". The proton beam has a mean energy value of 7 MeV and an appropriate holder was constructed to precisely place the cell culture disks. A gold leaf positioned above the petri dish deflects the beam into the cells through Rutherford scattering, ensuring uniform radiation distribution. This setup is crucial as without it, the beam would run parallel to the petri dish rather than being oriented vertically as intended. Expected dose rate is 0.2Gy/min.

Following the construction of the holder, the next step prior to the experiments was to perform simulations using MCNP6 (Monte Carlo N-Particle), Geant4, SRIM-TRIM, SIMNRA while for radiobiological damage prediction, MCDS (Fast Monte Carlo for Damage Simulation) and RMF model [1]. These combined simulations provide theoretical values for the maximum depth, energy loss (as determined by SIMNRA and SRIM-TRIM for quick calculations), and via MCNP6 and Geant4 analytical calculations for dose deposition into the cell (petri dish), flux of protons and LET (linear energy transfer).

In conclusion, a comparison was conducted between the results of MCNP6 and Geant4 simulations. The proton irradiation set up, its implementation and the results of this comparison will be presented and discussed in detail. The proton irradiation setup we propose will allow teams to conduct radiobiological experiments in Greece.

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Reaction mechanism for ^{8}B+^{nat}Zr at the sub-Coulomb energy of 26.5 MeV

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The reaction mechanism of ^{8}B + ^{nat}Zr below the Coulomb barrier, was investigated through elastic scattering and breakup measurements. The measurements were conducted at the sub-barrier energy 26.5 MeV (90% of the Coulomb barrier.), at the *TriSol* radioactive beam facility of the University of Notre Dame [1-3]. From these measurements, total reaction and breakup cross sections were extracted, along with the direct-to-total reaction cross section ratio, revealing the dominance of the breakup channel [3].

To gain deeper insight into the reaction mechanism, critical interaction distances were determined and compared with existing data for weakly- and well-bound projectiles on various targets, as a function of the product of the projectile and target atomic numbers.

Finally, total and breakup reaction cross sections for the studied systems, were reduced appropriately to eliminate the effect of the barrier [4] and the geometry [5] and compared among themselves.

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Evaluation of Environmental Radioactivity in Thessaly after Storm Daniel: A Pilot Study

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This work examines the level of radioactivity in regions of Thessaly (Central Greece) affected by disastrous floods after storm Daniel in September 2023. The purpose of this study is to map the specific radioactivity of natural isotope ^{40}K and of the artificial isotope ^{137}Cs in the affected areas. Specifically, the evaluation of post-flood ^{137}Cs dispersion may serve as an indicator of the environmental impact on the surrounding area, as the Thessaly plain is bordered by mountain ranges, which were among the most affected regions in Greece by the Chernobyl accident in 1986. Moreover, current agricultural activities involving potassium-based fertilizers are expected to contribute to the regional levels of radiopotassium, which is also known to be antagonistic to cesium cation in soils. To conduct this study, surface soil samples were collected from undisturbed locations (free of agricultural or urban activity) approximately a year after the floods. Following standard sample preparation, measurements were conducted with high-resolution gamma-ray spectroscopy at the γSPEC laboratory of the National and Kapodistrian University of Athens (NKUA). Based on the results, distribution curves were developed, and a value for absorbed dose of ionizing radiation and the external hazard index were calculated using UNSCEAR models. Notably, the specific radioactivity of ^{137}Cs was found to be 66 Bq/kg in Megala Kalivia (Trikala) and 30 Bq/kg in Keramidi (Trikala).

Study of Point Defects due to Ion Irradiation in the rMnFeCoNi High Entropy Alloy

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High Entropy Alloys (HEAs), formed by mixing multiple elements in near-equimolar ratios, exhibit remarkable mechanical and chemical properties. Alloys such as CrMnFeCoNi, known as the Cantor alloy, have drawn significant attention due to their single-phase structure, high strength-to-weight ratio, corrosion resistance, thermal stability, and exceptional performance under irradiation. Their enhanced resistance to radiation damage is primarily attributed to their chemical complexity, which affects several properties, most significantly, the mobility of radiation-induced defects, assumed to be lower than in pure metals and conventional alloys. Nevertheless, direct experimental studies of point defects in HEAs have not yet been performed.

This study presents the first direct experimental investigation of the properties of primary radiation defects in HEAs. A set of CrMnFeCoNi specimens was irradiated by 5 MeV protons at the NCSR "Demokritos" TANDEM accelerator. Irradiation was carried out at cryogenic temperature (8 K) to suppress defect mobility. The generation and evolution of radiation-induced defects were monitored in-situ by measuring the electrical resistivity (ER), which is extremely sensitive to the presence of lattice defects. A progressive increase in resistivity was observed with increasing irradiation dose, attributed to the accumulation of radiation defects. The estimated specific resistivity per Frenkel pair is significantly higher than that observed in simple metals. Following irradiation, the specimens underwent isochronal annealing up to 300 K. No substantial change in the radiation-induced resistivity was detected during annealing, suggesting that the generated defects remain largely stable below room temperature.

Multinucleon transfer in peripheral collisions of ^{86}Kr on ^{208}Pb at 25 MeV/nucleon

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A promising mechanism for the production of neutron-rich nuclei are multinucleon transfer reactions. Neutron rich nuclei above iron are part of the astrophysical r-process (rapid neutron capture process) which takes place during supernova explosions or binary neutron star mergers (kilonova explosions) [1]. Therefore, a detailed study of their production and their properties is essential.

In this work, we study projectile-like fragments resulting from the reaction of a ^{86}Kr beam with a ^{208}Pb target at 25 MeV/nucleon using experimental data obtained with the MARS spectrometer at the Cyclotron Institute of Texas A&M University in previous works of our group [2]. The data are systematically compared to theoretical model calculations.

Our analysis involved two models: the Deep Inelastic Transfer model (DIT) [3] and the Constrained Molecular Dynamics model (CoMD) [4]. Additionally, the GEMINI code [5] was used to simulate the deexcitation of primary fragments. We performed mass, angular and momentum distribution (p/A) analyses to gain insight into the reaction mechanism of peripheral collisions involving extensive multinucleon transfer.

Investigation of the dynamics of nuclear reactions in the Fermi energy regime (15–35 MeV/nucleon) is important as it advances our knowledge of nuclei towards the neutron drip line and the properties of the nuclear equation of state, both of which are key ingredients to our understanding of element synthesis in the cosmos.

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Ground-state lifetime measurements in Tellurium decay chains: Method and Results

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The isotopes of tellurium are located near the stability line on the isotopic chart, making them important for study in the context of nuclear theory and in terms of applications. In the present work, we will present a study of the radioactive decay chains of tellurium isotopes with mass numbers 117 and 115, aiming to investigate their ground-state half-lives as determined from an experiment conducted at the 9 MV Tandem accelerator at IFIN-HH in Romania. Key parts of this presentation will be a novel approach used to extract the experimental half-life values and its application to the experimental data obtained for the two tellurium decay chains. A comparison of the results obtained with and without the application of this method will also be presented to demonstrate its capabilities. The method does not rely on any input from the literature, and it allows for a significant reduction in the uncertainties associated with the extracted half-life values, thus enhancing the reliability and precision of the results.

Elastic Scattering of Medium-Mass Heavy-Ions and the Compressibility of the Nuclear Equation of State

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In this contribution, we present preliminary results on the elastic scattering channel of the ^{70}Zn (15 MeV/nucleon) + ^{64}Ni reaction, studied with the MAGNEX large-acceptance spectrometer at INFN-LNS. The present work is part of an extended effort by our group to investigate reaction mechanisms in the Fermi energy regime. In previous analyses, we focused on detailed studies of momentum per nucleon distributions (p/A), angular distributions, and production cross sections of various multinucleon transfer channels [1-3]. Here, we shift our attention to the elastic scattering and its sensitivity to the parameters of the nuclear equation of state (EOS). Experimental angular distributions were obtained and studied via comparisons with the Constrained Molecular Dynamics (CoMD) model [4], performed under different assumptions of nuclear matter compressibility (K = 200, 254, 308 MeV). The present results indicate sensitivity of the elastic scattering differential cross sections to the compressibility of the nuclear EOS. In parallel, we plan to explore optical model calculations to complement the microscopic approach and provide additional constraints on the nuclear equation of state.

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Neutron Activation Cross Section Measurement of the (n,2n) Reaction on ^{203}Tl at 14.6 MeV

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Studies of neutron-induced reactions have great significance; they contribute to a large extent to basic research in nuclear physics, but they also provide knowledge utilized for practical applications. Thallium is used for many purposes, such as electronics, pharmaceuticals, fiber optics, infrared detectors and nuclear medicine. Nevertheless, there is scarce information available regarding neutron-induced reactions on Tl isotopes. For example, the existing experimental data on the (n,2n) reaction are fairly inconsistent, especially in the energy region above ~14 MeV.

The main objective of the present work was to study the cross section of the (n,2n) reaction on ^{203}Tl using the activation technique. A natural TlCl pellet target was irradiated with a quasi-monoenergetic neutron beam, and delayed gamma neutron activation analysis was implemented in order to measure the cross section of the ^{203}Tl(n,2n)^{202}Tl reaction. Additionally, the reference reaction ^{27}Al(n,α)^{24}Na was used to determine the neutron fluence. The quasi-monoenergetic neutron beam was produced using the ^{3}H(d,n)^{4}He reaction in the 5.5 MV Tandem accelerator of the NCSR Demokritos neutron facility. The target and reference foil assembly were placed at approximately 2 cm from the tritiated titanium target, under an 80° degree angle. Therefore, while the initial incident neutron energy in a straight line was 16 MeV, at an 80° degree angle the incident neutron energy was 14.6 MeV, and the neutron fluence was lower by a factor of eight. A BF3 detector was placed 3 m from the neutron source to monitor the fluctuation of the neutron beam flux. Following the conclusion of the irradiation, the foils and pellet were placed in front of HPGe detectors, to measure the neutron-induced activity of the samples. The neutron fluence on the thallium chloride pellet, both at 80^0 and through the sample array, was investigated using Monte Carlo simulations -and more specifically the MCNP code- and subsequently normalized based on the neutron fluence of the reference aluminum foil.

Lastly, a theoretical study of all the existing data of the ^{203}Tl(n,2n)^{202}Tl reaction was performed using the nuclear reaction code TALYS, implementing the same parameters as those used in the theoretical study of other odd-even nuclei in this mass region, such as $^{191,193}Ir$ [1] and ^{197}Au [2].

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Investigating the nuclear structure of ^{116,118}Te

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The ^{116,118}Te isotopes, similar to their mirror partners Cd mid-shell isotopes across the Z=50 shell, show vibrational features in their ground-band states. However, recent density functional theory calculations [1, 2] and proxy-SU(3) studies [3] predict prominent shape coexistence in these nuclei. A verification of this requires experimental data. An experiment was conducted at the 9 MV Tandem Accelerator at IFIN-HH in Magurele, Romania, to populate excited states in ^{116,118}Te by means of the fusion-evaporation reaction mechanism. An ^{11}B beam at an energy of 35 MeV impinged on a ^{nat}Ag target. The subsequent γ decays were detected by the RoSPHERE array, equipped with 15 HPGe and 10 $LaBr_3$(Ce) detectors. The experiment provided data for spectroscopic analysis and highlighted the need for further refinement in experimental techniques, potentially employing the Doppler Shift Attenuation Method (DSAM) for the measurement of ground-state band lifetimes in the future. In this contribution the γ-spectroscopy analysis on ^{116,118}Te will be presented. Consecutive work will focus on fast-timing measurements to determine the lifetimes of excited states.

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Investigation of α-cluster Transfer in Peripheral Collisions of ^{40}Ca (12.3 MeV/nucleon) + ^{27}Al using the MARS Spectrometer at Texas A&M

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The phenomenon of α-clustering in nuclei plays a central role in shaping both nuclear structure and reaction dynamics, particularly in light and medium-mass systems [1,2]. Peripheral collisions provide optimal conditions for studying α-cluster transfer and nucleon exchange mechanisms [1]. In this work, we present a preliminary analysis of new experimental data on the reaction ^{40}Ca (12.3 MeV/nucleon) + ^{27}Al, performed at the Cyclotron Institute of Texas A&M University using the MARS recoil separator. Peripheral collisions involving ^{40}Ca provide an excellent testing ground, as this nucleus is known for its pronounced cluster substructure [2,3]. The primary goal of this work is the identification of projectile-like fragments (PLFs) resulting from the transfer or removal of light clusters (d, t, ^{3}He, ^{4}He) from the projectile to the target and vice versa and the study of their yield and p/A distributions.
The particle identification procedure is based on the response of a two-element silicon detector telescope (ΔE, E_r) at the focal plane of MARS recoil separator. The atomic number (Z), ionic charge (q), and mass number (A) were reconstructed through calibrated correlations involving energy loss, residual energy, focal-plane position and magnetic rigidity. This procedure enabled event-by-event isotopic identification of the reaction products in terms of Z, q and A, following established particle identification techniques developed in previous studies with MARS [4].

This analysis aims to isolate cluster transfer channels with high resolution and provide a solid experimental basis for the study of reaction dynamics. Future steps include the extraction of isotopic yield and momentum (p/A) distributions for the identified fragments. Subsequently, these results will be compared with theoretical models (DIT, CoMD) [5,6], to investigate the presence of direct transfer mechanisms and clustering effects. The present study contributes to ongoing systematic efforts to investigate clustering and multinucleon dynamics from the Coulomb barrier to the Fermi energy regime across different nuclear systems.

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Study of Deuteron-Induced Reactions in ^{18}O in the Framework of NRA

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Oxygen (natural abundance: ^{18}O: 0.187%, ^{17}O: 0.0367%, and ^{16}O: 99.738%) is a highly active chemical element found in ~21% of the Earth's atmosphere. Its chemical activity causes it to corrode metals and penetrate minerals in the Earth's crust, damaging, among other things, sensitive technological items. Furthermore, oxygen is essential to the survival of all living creatures. These properties make it particularly interesting for scientific research and significant for detection and depth profiling analysis using Ion Beam Analysis Techniques (IBA).

Among the IBA Techniques, Nuclear Reaction Analysis (NRA) is the most appropriate due to its high Q-values, resulting in isolated peaks. Also, d-NRA allows the simultaneous detection of other light elements in the target and of their respective stable isotopes. In terms of the three oxygen isotopes, the ^{16}O abundance is too high and the ^{17}O one too low, rendering ^{18}O, and thus the enriched targets in ^{18}O, suitable for scientific applications such as Stable Isotope Tracing. In addition, deuteron-induced nuclear reactions with ^{18}O have larger Q-values than proton-induced ones, making them particularly suitable for thin targets on thick backings, such as the one utilized in the present work. Thus, given the limited literature on $^{18}O(d,a_{0-3})^{16}N$ differential reaction cross-section datasets suitable for d-NRA applications, research into this field was strongly motivated.

The experiment was conducted at the 5.5 MV TN11 Tandem Accelerator of the National Centre for Scientific Research (N.C.S.R.) "Demokritos", Athens, Greece. Deuterons were accelerated to $E_{d,lab}$=1470-2160keV in various steps and were led to a cylindrical high-precision goniometric chamber. For particle detection, six SSB detectors were secured on rails in the chamber, covering the backscattering angles of 120°, 130°, 140°, 150°, 160°, 170°. The target used was a thin layer of Ta_2O_5 -enriched in ^{18}O- created on the surface of a thick tantalum foil, via controlled, progressive anodization. The obtained results were compared with existing ones found in the literature, in the energy regions where it was possible.

Gamma-ray spectroscopic analysis around the N=104 mid-shell for ^{176,177}Yb and ^{182}W nuclei*

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Even-even Yb and W isotopes around the N=104 mid-shell region are known to present deformation. The ground-band states of these nuclei are well described by the SU(3) symmetry (rigid-rotor shapes). Excited states of isotopes in the region, namely ^{176}Yb and ^{182}W, were populated through Coulomb excitation and fusion-evaporation reactions, in an experiment performed at IFIN-HH in Magurele, Romania. The γ-spectroscopy of these nuclei will be presented in this contribution. Additionally, γ-spectroscopy results for the even-odd ^{177}Yb nucleus, populated by the 1-neutron transfer reaction mechanism, will be presented. Contradictory to the collective description of the ground-band excitations in ^{176}Yb and ^{182}W isotopes, the excited states of this nucleus can be described by single-particle excitations. In the experiment a monoisotopic ^{176}Yb target was bombarded by ^{9}Be ions at a beam energy of 38 MeV. The populated excited nuclear states emitted γ rays which were detected using the RoSPHERE array, equipped with 10 HPGe and 15 LaBr3(Ce) detectors. The γ-spectroscopy analysis of the data contributes to the evaluation of the available data in this mass region, while ongoing work is expected to provide further insights for the nuclear structure of these rare-earth isotopes, where scarcity of available data leaves several theoretical questions unanswered.

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Time-of-Flight Neutron Transmission Measurements on ^{nat}Cu at the GELINA Facility

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Natural copper serves as an important structural material for critical assembly configurations and fusion reactors. The existing discrepancies in the experimental and evaluated data of neutron induced total cross section measurements on the two stable copper isotopes (^{63,65}Cu) have raised the need for new neutron transmission measurements on copper.

In the present study, neutron transmission measurements have been carried out at the GELINA facility of JRC-Geel, on several samples, consisting of natural copper (^{nat}Cu), to confirm the neutron resonance parameters and the total cross section of copper in the energy range of 1 to 100 keV. The measurements were performed at the 50 m transmission station of flight path 4. Three thick samples were measured: two metallic cylinders composed predominantly of ^{nat}Cu and one brass alloy containing 38% ^{nat}Zn. Black resonance filters (Na, Co, W) were placed in independent and automatic filter exchangers, close to the position of the samples, to quantify the background contribution at 2850 eV, 132 eV and 18 eV, respectively, and to determine the corresponding time dependence. A NE912 Li-glass scintillator with a height of 6.35 mm and diameter of 151.6 mm was used to detect the neutron beam passing through both the sample and the filters. The AGS code [1, 2] was used to obtain the experimental transmission spectra from the time-of-flight ones.

A comparison between the experimental data and the theoretical transmission factors, calculated with the JEFF-3.3 evaluated cross section data [3], was conducted using the REFIT code [4]. The results highlight significant differences, particularly at higher energies, underscoring the need for updated and accurate datasets that will help improve nuclear data libraries and support applications, such as reactor design, safety assessments, and benchmarking analyses, particularly in cases where copper is used as a structural material. The analysis procedure, as well as the results of this work will be presented and discussed. The data obtained from the present work are intended for submission to the EXFOR database.

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OpenTRIM: an open source Monte-Carlo simulation code for ion transport in materials

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The transport of energetic ions in materials is highly important across a wide range of research fields, including nuclear physics, space and astrophysics, plasma physics, fusion research, and ion beam materials characterization. In particular, the radiation damage sustained by materials depends heavily on ion transport within the collision cascades generated by high energy irradiating particles, such as neutrons or ions. The resulting distributions of vacancies and implanted atoms are typically estimated through numerical simulations. One of the most widely used codes for such calculations is SRIM, which employs an extensive database of ion stopping powers and a convenient user interface.

However, significant discrepancies have been observed in SRIM's damage estimates when using different simulation settings. These inconsistencies are often difficult to interpret due to limited documentation and a lack of information regarding how certain aspects of the underlying models are implemented.

To address these limitations, we developed OpenTRIM, a novel, highly efficient Monte Carlo code for ion transport simulations, written in C++. OpenTRIM is open source, ensuring full transparency of its modeling assumptions and implementation. It employs well-established ion simulation techniques such as the binary collision approximation (BCA) and a selection of screened Coulomb interatomic potentials. In addition, the code provides more detailed statistics on defect generation and energy partitioning per damage event than many existing simulation tools. Designed for both flexibility and usability, OpenTRIM features a graphical user interface as well as batch-mode functionality for automated simulations.

In this contribution, we present the main components and architecture of the code and compare results from representative simulations to those obtained using SRIM and other established tools.

Measurement of the ^{234}U(n,f) cross-section with Micromegas Detectors*

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The neutron-induced fission cross section of ^{234}U was measured for incident neutron energies in the range of 0.8 - 1.5 MeV, using a setup of MicroMegas gaseous detectors and quasi-monoenergetic neutron beams. The measurement took place at the Tandem Van de Graaff accelerator facility of the Institute of Nuclear and Particle Physics of the National Center for Scientific Research "Demokritos", in April 2025.

The quasi-monoenergetic neutron beams were produced via the ^{7}Li(p,n)^{7}Be reaction, using proton beams with energies E_p= 2522, 2569, 2617, 2665, 2712, 2760, 2818, 2857, 2905, 3002, 3100 and 3197 keV. The generated neutron beam then entered the experimental chamber filled with $ArCO_2$ (90:10) gas, that contained the actinide targets (^{234}U, ^{235}U, ^{237}Np) set as electrodes within the corresponding MicroMegas detectors. In order to achieve the highest possible transmission efficiency of ionization electrons and determine the optimal drift and mesh voltage of the detector, the detectors' transparency and gain were examined. The ^{235}U(n,f) and ^{237}Np(n,f) reactions were used as reference reactions. The analysis of the experimental data, as well as the first results will be presented.

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Investigation of the Yb and W isotopic chains using the confined β-soft rotor model

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The Confined β-soft (CBS) rotor model [1] provides a simple collective approach in the region between the spherical vibrator and the axially deformed rotor limit for axially symmetric prolate (γ≈0) shapes. Even-even isotopes of Ytterbium and Tungsten serve as a good testing ground for exploring fundamental aspects of nuclear structure, as their $R_{4/2}$=E(4+)/E(2+) ratio lies between 2.9 and 3.333. In the present study, the CBS formalism is applied [2] to calculate the energies of the ground-state band, the associated B(E2) transition rates and the β-band excitations, directly comparing these predictions to available experimental data. The results demonstrate that CBS succeeds in reproducing the observed spectra and transition strengths for the case of axially symmetric isotopes of Yb ans W.

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Measurement of the differential cross sections of the $24Mg(p,p'\gamma)$ reaction at three detection angles relevant to the PIGE technique

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Magnesium is a lightweight element extensively utilized in technical, medical, and industrial applications. Consequently, a technique to quantify magnesium in complex matrices is deemed essential. The predominant least-destructive procedures to meet this end are those involving Ion Beam Analysis. Particle Induced Gamma-ray Emission (PIGE) is a technique particularly adept in detecting magnesium. However, the implementation of PIGE is often impeded by the lack of accurate and reliable differential cross section datasets over a broad energy and angular range and the present work aimed at contributing in this field.

The differential cross-section measurements took place at the 5.5 MV Tandem Van de Graaff accelerator of NCSR "Demokritos". The energy of the proton beam ranged from 2300 keV up to 5000 keV with varied steps of 5, 10, 20, 40, and 50 keV. The detection angles were set at 90°, 125°, and 150°. The implemented target was a thin magnesium layer evaporated on top of a thick tantalum backing. For the detection of the main γ-ray at $E\gamma$=1369 keV, three High Purity Germanium detectors (HPGe) were used, set on a high-accuracy goniometric table. The detectors were carefully shielded to minimize the effects of parasitic events. Additionally, a thick MgO target was used to validate the differential cross-section measurements through a benchmarking process. The energy of the proton beam ranged from 2300 keV to 5000 keV with a 300 keV step for the thick target gamma-ray measurements.

In the present work the preliminary differential cross section results are presented, along with previously reported ones in literature [1, 2, 3], and an attempt is made to explain the occurring similarities and discrepancies. The total uncertainty budget is also presented in detail.

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Hauser-Feshbach studies of α-capture reactions in molybdenum isotopes

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One of the foremost aims of Nuclear Astrophysics is to unravel the elemental and isotopic make-up of our solar system. Although our understanding of most nuclides has advanced considerably, a group of neutron-deficient isotopes -the so-called p nuclei-remains enigmatic, since they cannot be synthesized by the slow (s) or rapid (r) neutron-capture processes that account for the bulk of heavy-element production. Instead, p-nuclides are thought to arise during the high-temperature stages in massive stars-either just before or during the supernova explosion-through a complex interplay of photodisintegration, proton and alpha captures, and subsequent $\beta^{\pm}$ and electron-capture decays.

Within this framework, the reactions ^{94}Mo(α,γ)^{98}Ru and ^{94}Mo(α,n)^{97}Ru are of particular importance. The isotope ^{94}Mo occupies a critical branching point in the γ-process network: its abundance and the rates of alpha-capture channels directly influence how nucleosynthetic flow proceeds toward heavier p nuclei. Understanding the behavior of ^{94}Mo under stellar conditions, is therefore essential for refining theoretical models of p-nucleus formation and for constraining the temperature and density environments in which these rare, neutron-deficient isotopes are forged. In the present thesis, the reaction cross sections of ^{94}Mo(α,γ)^{98}Ru and ^{94}Mo(α,n)^{97}Ru are studied, near the astrophysically relevant energy window (Gamow), employing the statistical model Hauser-Feshbach. Using the TALYS 2.0 code, various different α-optical model potentials, nuclear level densities and gamma strength functions are used to estimate the reaction cross sections and the results are compared to the existing experimental data.

Flux Determination of the 17MeV quasi-monoenergetic Neutron Beam at NCSR "DEMOKRITOS" using the Multiple Foil Activation technique

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Neutron induced experiments that take place at NCSR "DEMOKRITOS" often use quasi-monoenergetic neutron beams and thus require a thorough determination of the neutron flux across the entire energy spectrum. A common reaction for neutron production is ^{3}H(d,n)^{4}He, which leads to a flux peak ranging from 15MeV to roughly 20MeV. In this experiment the beam was produced by a tritiated Titanium target (TiT) with an activity of 737GBq and a thickness of 2.12mg/cm^2, placed on a 1mm thick copper backing.

The goal of this work was the full characterization of the neutron beam at 17MeV utilizing the Multiple Foil Activation technique (MFA) in combination with the SAND-II unfolding code. To achieve this, the following reference reactions were selected: ^{27}Al(n,α)^{24}Na, ^{197}Au(n,2n)^{196}Au, ^{197}Au(n,γ)^{198}Au, ^{93}Nb(n,2n)^{92m1}Nb, ^{59}Co(n,2n)^{58}Co, ^{59}Co(n,α)^{56}Mn, ^{115}In(n,γ)^{116m1}In, ^{115}In(n,n΄)^{115m1}In, ^{113}In(n,n΄)^{113m}In, ^{56}Fe(n,p)^{56}Mn, ^{58}Ni(n,p)^{57}Co, ^{58}Ni(n,2n)^{57}Ni, ^{191}Ir(n,2n)^{190}Ir, ^{191}Ir(n,2n)^{190m4}Ir and ^{193}Ir(n,γ)^{194}Ir. The targets were placed back-to-back within a cylindrical holder and positioned at 1.7cm away from the tritium-air dividing surface, where they were irradiated for 7.75 hours. The delayed gamma rays from the residual nuclei were then measured using three High Purity Germanium detectors (HPGe), two at "DEMOKRITOS" with an internal efficiency of 80%, and one at the Department of Physics of the National Technical University of Athens (N.T.U.A) with an internal efficiency of 40% and shielding. The beam fluctuations were monitored with the help of a Boron Trifluoride detector (BF3) placed at about 3m from the tritiated Titanium source, while the gamma-ray self-absorption and the flux variations within each target were calculated using the MCNP5 Monte Carlo code. The Saturated Activity for each target foil acted as input for the SAND-II code, along with well-documented Cross-Sections from the IRDFF-II, ENDF/B-VIII.1 and CENDL-3.2 libraries, to derive the full-spectrum flux of the 17MeV beam.

Setup and calibration of in-situ gamma-ray spectrometer for marine applications*

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Monitoring radioactive isotopes in aquatic environments is essential for environmental safety, early detection of nuclear accidents and research in various fields like geology, seismology and oceanography.Mini KATERINA is a gamma ray spectrometer developed at the HellenicCentre for Marine Research (HCMR) for monitoring directly and continuously in the sea thegamma-ray intensity rates of radionuclidesby integrating it toautonomous and mobile platforms.It uses a 2'x2' NaI(Tl) scintillation crystal coupledwith a Silicon Photomultiplier (SiPM) in order to reduce dimensions, weight and maneuverability in the marine environment. The system ishousedinto a custom-made watertight enclosure for underwater deployments.In the present work calibrationexercises of the system were performed with and without itsenclosure. First,gamma-ray spectra were acquired using point sources in the air environment with a special frame and geometry. The measurements were compared with a similar crystal with a traditional photomultiplier (PMT) using the same point sources and measurement geometry. Next, the complete detection system with the enclosure was immersed in a water tank with radioactive isotopes in order to calibrate it in terms of energy, energy resolution and efficiency. The activity concentrations of the gamma-ray emitters enriched into the waterwas determined byapplying thecalibrated KATERINA underwater spectrometer [1]. Simulation results were obtained using the MCNP5 code [2] reproducingwell the experimental data.

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Characterization of BC501A Liquid Scintillator for Neutron-Gamma Discrimination using the Pulse Shape Analysis Technique

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Sensitive and precise detection systems are essential for discriminating and detecting photons and neutrons in a mixed field. In the first part of this study, experiments were conducted using the BC501A liquid scintillator at the National Centre for Scientific Research "Demokritos." Initially, applying the pole-zero cancellation technique, an analog electronic circuit was implemented to achieve proper neutron-gamma discrimination. Subsequently, the performance of the MPD-4 [1] digital pulse shape discriminator was investigated, enabling a comparative assessment of the minimum detectable neutron energies between analog and digital circuits.

The scintillator was tested with various photon sources, including ^{60}Co, ^{137}Cs, ^{22}Na, and ^{241}Am for calibration and to evaluate detection efficiency under high counting rate conditions, and the detector demonstrated stable performance and resistance at very high counting rates. Along with that, the gamma emission line of ^{241}Am at 59.6 keV was identified by adjusting the pulses' gain. Furthermore, time discrimination between photons and neutrons was examined using an ^{241}Am-^{9}Be source. The minimum detectable and discriminable neutron energy was determined to be 1.39 MeV, aligning well with values reported in the literature [2] and thus validating this experimental approach.

In the second part of the experiment, the MPD-4 module— a four-channel pulse shape discriminator— was investigated. In this case, the minimum neutron energy was reduced by at least a factor of two compared to analog electronics, thus allowing for the effective detection of neutrons with energies down to a few hundred keV.

In conclusion, the digital approach offers improved discrimination at lower neutron energies using the MPD-4 device. Future work will focus on high-resolution digitizers to further improve neutron detection performance at low energies.

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Estimation of cross section for proton-induced reactions in stable Yb isotopes at astrophysical energies

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In this work, we address an open problem in nuclear astrophysics: the synthesis of elements heavier than iron. While the formation of light elements up to iron is well understood, the origin and abundance of heavier nuclei, particularly those with atomic mass number A > 56, remain under investigation. Among the proposed mechanisms, proton-capture reactions play a central role for *p*-nuclei, especially in extreme astrophysical environments. In this study, we focus on the theoretical modeling of proton-capture reactions on stable isotopes of Ytterbium (Yb). Although Yb is not a *p*-nucleus itself, its isotopes (^{168}Yb to ^{176}Yb) are relevant to understanding nucleosynthesis pathways near the limits of stability. Due to the scarcity of experimental cross-section data in the energy range of 1–8 MeV, we have employed the Hauser-Feshbach model to simulate (p,γ) reactions and extract cross section values and the astrophysical S-factor, running TALYS v2.0 with various parameter options. Our main motivation is bifacial: first, to prepare the grounds for experimental work in this series of isotopes at such low energies, and second, improve our understanding of heavy element formation via the proton-capture process in an energy region, where the high Coulomb barrier works as an impeding factor.

Calibration of CZT detector systems for laboratory measurement of marine sediment

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This study presents the calibration of two detection systems, consisting of a 10 mm^3 CdZnTe crystal, for on-site and laboratory measurements of marine sediments and terrestrial soil. They are compact (25mm×25mm×63mm), portable (only 60 g in weight) and ideal for outdoor applications as they operate in a wide range of environmental temperatures (0 - 50 °C) without cooling. The detector's crystal is of high density, approximately 5.8 g cm^{-3}, denser than a typical NaI crystal (3.7 g cm^{-3}) or even an HPGe (5.3 g cm^{-3}) however, its small volume significantly reduces the detection efficiency. In this work, using reference sources, each detector was calibrated (energy and efficiency), and the minimum detectable activity (MDA) was estimated. For validation purposes, measurements of a voluminous soil sample of known activity followed, yielding a satisfactory agreement. Moreover, a new setup combining the two systems was designed and implemented, resulting in an important improvement of the MDA.

Keywords: CZT detector, experimental calibration, marine sediment samples, soil samples

Design and operation of an Inertial Electrostatic Confinement Fusion Device (FUSOR)

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This study presents the design, construction, and initial operation of a model Inertial Electrostatic Confinement (IEC) fusion device, commonly referred to as a "Fusor," developed for educational purposes at the Fusion Technology Group laboratory of NCSR "Demokritos". Originally proposed by P. T. Farnsworth in the 1950s, the IEC concept confines ions within a spherical virtual potential well generated by a hollow mesh grid.

In the current implementation, the grid was fabricated using 0.5 mm nickel wire, secured via spot-welded joints. A 12 kV high-voltage power supply, interfaced through a custom-built feedthrough based on an automotive spark plug, was employed to energize the grid. Initial experiments were conducted using argon gas to produce and confine plasma, enabling characterization of the device's operational conditions. This work outlines the system design, analyzes the resulting electrostatic confinement fields, and reports preliminary operational results.

Simulations for Optimization of Proton Dose Delivery Using the Advanced Markus Chamber*

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The Advanced Markus chamber [1] is a vented, plane-parallel ionization chamber widely used in proton dosimetry, particularly in cases involving narrow spread-out Bragg peaks or steep depth-dose gradients. As part of the NuCapCure project [2], a series of *in vitro* and animal model irradiation experiments will be conducted to evaluate the efficacy of novel radiosensitive compounds designed to enhance the cancer cell-killing potential of proton therapy.

To support these experiments, Monte Carlo simulations were carried out using the MCNP 6.1 code [3] to model the irradiation setup at the Oslo Cyclotron Laboratory (OCL), which employs the MC-35 Scanditronix AB cyclotron. The computational model included the 16 MeV proton source, a tungsten filter, a beam monitor, and the Advanced Markus chamber. Particular attention was given to the effect of the chamber's entrance window, as it influences the location of the proton Bragg peak. The results of this study allow the optimal positioning of both the Markus chamber and the biological samples, maximizing proton dose delivery during the NuCapCure irradiation experiments.

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Development and construction of an Arduino-based Geiger-Müller detector for radiation monitoring applications

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The design and construction of a low-cost, Arduino-based Geiger–Müller detector (ArbaGeM) tailored to the educational and research needs of the Nuclear Physic Laboratory at the National and Kapodistrian University of Athens is presented. The compact system integrates a DFRobot Geiger–Müller module, LCD-driven interval selector, real-time interrupt counting and SD logging, delivering portability, rapid start/stop operation and fully automated data capture. The device is encapsulated in a sturdy 3D-printed container, especially designed to offer protection, portability and ease of operation.

As an application two devices have been recently installed and operated seamlessly during the Spring Semester Introductory Nuclear Lab at NKUA to study the statistical nature of beta decay. A ^{90}Sr β-source was used and the device recorded ~6’000 time-window samples at three counting intervals. Histogram fits and χ^2 goodness-of-fit tests confirmed Poisson behavior at small and medium intervals, while Monte Carlo simulations (10’000 pseudo-experiments) demonstrated convergence to the Gaussian distribution for large intervals (λ>30), in excellent agreement with Central-Limit-Theorem expectations. Two more devices are under development. Incorporation of additional sensors (temperature, humidity, CO2 etc) to provide a low-cost, user-friendly, portable monitoring system for various research applications is also a near-future plan.

Figure 1. *The developed ArbaGEM device*