HNPS 2023 NTUA

Book of Abstracts

31st Annual Symposium of HNPS – Program

FRIDAY, 29/9/2023

08:30-09:00	**Registration, Main Auditorium**
09:00-09:30	**Welcome Addresses**
Session 1: Invited Presentations, Chair: R. Vlastou	
09:30-10:00	*A. Gurbich, 'Determination of the Stopping Power and Range of Ions in Matter by Resonance Methods'*
10:00-10:30	*A. Chebboubi, 'Study of fission products characteristics with the LOHENGRIN spectrometer'*
10:30-11:00	*A. Pakou, 'Global studies of reactions with weakly bound nuclei at sub- and near- barrier energies'*
11:00-11:30	**Coffee Break**
Session 2: Neutron Physics, Chair: M. Diakaki	
11:30-11:45	*V. Michalopoulou, 'Measurement of the 235U(n,f) cross-section using the 10B(n,α) reaction as reference at EAR-2 of n_TOF at CERN: first results'*
11:45-12:00	*S. Dede, 'Production of actinide targets using Solution Combustion Synthesis and the effects after Ion and Neutron irradiation'*
12:00-12:15	*S. Chasapoglou, 'Study of (n,x) Reactions on Ge isotopes in the Energy Range Between 15.5 and 18.9 MeV Implementing Enriched Ge Targets'*
12:15-12:30	*G. Gkatis, 'Angular distribution measurements of neutron elastic scattering by natural carbon'*
12:30-12:45	*N. Kyritsis, 'First Results from the 243Am(n,f) cross-section measurement at the nTOF facility at CERN'*
12:45-13:00	*K. Kaperoni, 'Characterization of Diamond Detector Response to Neutron Beams at the NCSR "Demokritos"'*
13:00-13:15	*S. Goula, 'Charged particle spectroscopy using a ring-shaped silicon nTD detector: First results on the detector's response using a neutron converter target at n_TOF/CERN'*
13:15-14:30	**Photo + Light lunch**
Session 3: Nuclear Reactions, Nuclear Astrophysics, Nuclear Structure, Chair: Th. Mertzimekis	
14:30-14:45	*M. Kokkoris, 'Measured, Evaluated, and Benchmarked Differential Cross Sections for Proton Elastic Scattering on natN in the Energy Range E=3-5 MeV'*
14:45-15:00	*A. Tsantiri, 'Constraining the Astrophysical γ Process: Cross Section Measurements of (p,γ) Reactions in Inverse Kinematics'*
15:00-15:15	*S. Koulouris, 'Multinucleon Transfer Reactions in the 70Zn (15 MeV/nucleon) + 64Ni System: Detailed Studies*
15:15-15:30	*K. Palli, 'Elastic Scattering of 8B+90Zr at Sub-barrier Energies'*
15:30-15:45	*A. Zyriliou, 'Nuclear structure investigations in medium–weight isotopes'*
15:45-16:00	*M. Efstathiou, 'Nuclear lifetime measurements around Z=50'*
16:00-16:15	*P. Vasileiou, 'Fast-timing measurements of nuclear lifetimes in the Z~50 region'*
16:15-16:30	*S. Pelonis, 'Design and simulations of a linear Paul trap for single-ion spectroscopy'*

16:30-17:00	**Coffee Break**

Session 4: Neutron Physics, Nuclear Astrophysics, Nuclear Reactions, IBA, Chair: A. Lagoyannis

17:00-17:15	*A. Stamatopoulos, 'The 88Zr study at DICER at LANSCE'*
17:15-17:30	*P. Gastis, 'Fission-Fragment Mass Spectrometry at the Los Alamos Neutron Science Center Facility'*
17:30-17:45	*P. Tsintari, 'Direct (p,n) Reaction Measurements of Astrophysical Interest Using Radioactive Beams: A Novel Approach with SECAR'*
17:45-18:00	*N. Dimitrakopoulos, 'Extraction of the Nuclear Level Density of the neutron rich isotopes 68Cu & 65Ni using the LANSCE/WNR neutron beams and the evaporation technique'*
18:00-18:15	*M. E. Stamati, 'Nuclear Astrophysics at NEAR/n_TOF: Data analysis of first MACS measurements'*
18:15-18:30	*E. Ntemou, 'Lattice-site location of Mn in Mn-rich Sb2Te3 topological insulators using MeV ion channeling'*
18:30-18:45	*F. Maragkos, 'Systematic study of 3He – induced reactions and elastic scattering on light isotopes for applications in Ion Beam Analysis'*
18:45-20:45	**General Assembly of HNPS**
21:00	**Conference Dinner at Liatiko Restaurant**

SATURDAY, 30/9/2023

Session 5: Theoretical Nuclear Physics, Chair: A. Martinou

09:00-09:15	*D. Bonatsos, 'Shape/phase transitions and shape coexistence in even-even nuclei'*
09:15-09:30	*Ch. C. Moustakidis, 'The multi-messenger nuclear physics of neutron stars'*
09:30-09:45	*V. Prassa, 'Covariant density functional description of shape phase transitions and shape coexistence in heavy nuclei'*
09:45-10:00	*D. K. Papoulias, 'Probing new physics with nuclear recoil data from COHERENT'*
10:00-10:15	*K. Folias, 'Study of quarkyonic matter and applications in neutron stars'*
10:15-10:30	*M. Vikiaris, 'Supramassive compact objects with neutron star and dark matter origins'*
10:30-10:45	*P. Laskos-Patkos, 'Signatures of hadron-quark phase transition through the r-mode instability in twin stars'*
10:45-11:15	**Coffee Break**

Session 6: Instrumentation, Cultural Heritage, Nuclear Materials, Chair: Th. Vasilopoulou

11:15-11:30	*I. Savvidis, 'Large Volume Spherical Proportional Counter for Dark Matter Detection From the Φ=60cm Sphere to the Φ=3m Sphere and the New Design of the Sensors'*
11:30-11:45	*A. G. Karydas, 'Fundamental X-ray studies using Synchrotron Radiation'*
11:45-12:00	*E. Androulakaki, 'A modular custom-built Macro-XRF spectrometer for Heritage Science'*
12:00-12:15	*G. Savvidis, 'Reactor neutrino detection with the NEWS-G3 experiment'*
12:15-12:30	*S. Pantousa, 'Fe+ ion irradiation of Fe-10at%Cr alloys at 300oC: Magnetic and structural effects'*
12:30-12:45	*V. Chatzikos, 'Positron Annihilation Study of Neutron-Induced Defects in Single Crystal Tungsten: Effects of Irradiation Dose and Temperature'*

12:45-13:00	*M. Giamouridou, 'Proton irradiation studies of Uranium Nitride (UN) and (U,Zr)N composite fuels'*
13:00-13:15	*I. Goula, 'A study on the wall effect of Spherical Proportional Counter for long-range particle detection'*
13:15-14:15	**Light lunch**
14:15-15:15	**Poster Session**
Session 7: Environment, Chair: A. Ioannidou	
15:15-15:30	*A. Clouvas, 'A comparative analysis of Cs-137 soil migration over a thirty six years study period (1987-2023) : Experimental measurements vs. compartment model predictions'*
15:30-15:45	*G. Trabidou, 'Inventory of natural radionuclides in the Greek mineral springs'*
15:45-16:00	*D. L. Patiris, 'Radioactivity mapping of beach sand by mobile in situ gamma-ray spectrometry'*
16:00-16:15	*K. Karfopoulos, 'Joint IAEA/EEAE Regional Intercomparison Exercise on Radioanalytical Analysis of NORM Samples'*
16:15-16:30	*N. Salpadimos, 'Atmospheric Dispersion Software Intercomparison Exercise and Sensitivity of Results'*
16:30-16:45	*I. Madesis, 'αSPECT: Adaptation of existing radon detectors to deep-sea operation'*
16:45-17:00	*G. Siltzovalis, 'Validation and Testing of Novel Underwater Sensors at the Hydrothermal Vent Field of Milos'*
17:00-17:15	*F. K. Pappa, 'Radioactivity in building materials used in Lesvos, Greece'*
17:15-17:45	**Coffee Break**
Session 8: Nuclear Theory, Nuclear Reactions, Chair: Ch. Tsabaris	
17:45-18:00	*E. Krotscheck, 'Triplet pairing in neutron matter'*
18:00-18:15	*T. S. Kosmas, 'Open problems in conventional and exotic muon physics: Predictions of numerical solutions of fundamental differential equations'*
18:15-18:30	*O. Sgouros, 'A global description of the 18O+48Ti collision within the NUMEN project'*
18:30-18:45	*V. Soukeras, 'Recent results in the study of the 20Ne + 130Te collision within the NUMEN project and future perspectives'*
18:45-19:00	*P. T. Oikonomou, 'Colour-Flavour Locked Quark Stars in light of the Compact Object in HESS J1731-347 and the GW190814 Event'*
19:00-19:15	*E. Charatsidou, 'Advancements in Nuclear Engineering and Nuclear Materials: Insights from Sweden's SUNRISE Centre and Initiatives on Public Acceptance'*
19:15	**Closing Remarks for HNPS 2023**

POSTER SESSION, SATURDAY 30/9/2023, 14:15-15:15

P-1	*L. Amanatidis, 'Flux determination for the 18 MeV Neutron Beam at NCSR "DEMOKRITOS" using the multiple foil activation method'*
P-2	*M. J. Anagnostakis, 'An Improved Technique for Monitoring Radon Progeny in Ambient Air'*
P-3	*Z. Bari, 'Cross Section Measurements and Theoretical Study of the 174,176Hf(n,2n)173,175Hf Reactions'*
P-4	*A. I. Barlas, 'A comparative study of γ-ray spectrometers in various applications'*

P-5	*G. Eleftheriou, 'High resolution gamma-ray spectrometry of environmental samples at MERL, HCMR'*
P-6	*O. Fasoula, 'Detailed Study of Multinucleon Transfer Mechanisms in 86Kr + 64Ni at 15 MeV/nucleon'*
P-7	*F. P. Gelatsoras, 'A study of natural radioactivity in urban parks'*
P-8	*S. Georgiou, 'Microdosimetric Modelling of Neutron Capture Therapy Effectiveness'*
P-9	*Ch. Giannitsa, 'Signatures of Clustering and Cluster Transfer in Peripheral Collisions of 40Ar on 64Ni at 15 MeV/nucleon'*
P-10	*K. Gkatzogias, 'Detailed Studies of Multinucleon Transfer in 40Ar (15 MeV/nucleon) + 64Ni via High-Resolution Studies of Momentum Distributions'*
P-11	*M. Kagioglou, 'Neutron Induced Reactions on 203Tl at 15.7 MeV, 16.0 MeV and 18.0 MeV'*
P-12	*A. Kalamara, 'Neutron Dosimetry at HK-1 beam line of LVR-15 reactor for Biomedical Sample Irradiations'*
P-13	*A. Karakaxi, 'Study and Validation of Differential Cross Sections for Deuteron-Induced Reactions in 13C, Suitable for NRA'*
P-14	*A. Kotsovolou, 'Differential Cross-Section Measurements of the 18O(p, a0) Reaction at 170o and 160o, in the Energy Range Ep=1-2MeV, for NRA Purposes'*
P-15	*I. Koukouletsou, 'Dose distribution in boron neutron capture therapy for the treatment of brain cancer'*
P-16	*R. Kourgiantakis, 'Radiological characterization of ITER materials'*
P-17	*D. Lazaraki, 'Gamma-spectroscopic analysis of NORM samples'*
P-18	*E. Mitsi, 'Quantifying athermal recombination corrected radiation damage in ion irradiated Fe and W utilizing the SRIM code'*
P-19	*N. G. Nicolis, 'Monte-Carlo calculations of evaporation and fission in excited spallation reaction fragments'*
P-20	*M. Peoviti, 'Talys calculations for α capture reactions on Cu isotopes'*
P-21	*S. K. Roumelioti, 'Radio-dating method of 210Pb in a marine sediment core from the deep basin Northern of Skyros Isl., Aegean Sea'*
P-22	*P. K. Rouni, 'EDXRF anlysis of metallic powders used in 3D printing of dental prosthetics'*
P-23	*P. E. Sideri, 'An operational radiation safety intervention: Minimizing dose in lab spaces due to photon sources in adjacent storage room'*
P-24	*A. Skouloudaki, 'Study of 233U(n,f) reaction's cross section using Micromegas detectors'*
P-25	*V. Theodoropoulos, 'A study of the nuclear structure of even-even Te isotopes using the IBM-1'*
P-26	*I. Tsormpatzoglou, 'Cross section biasing in 3H(d,n)4He reaction using the GEANT4 toolkit'*
P-27	*T. Zafeiris, 'Radioactivity studies in soils from Northwestern Greece'*
P-28	*A. Ziagkova, 'Installation of the new TOF – ERDA setup at N.C.S.R. "Demokritos"'*
P-29	*A. Ioannidou, 'Spectroscopic limitations of hand-held γ-spectrometers'*
P-30	*Th. V. Papavasileiou, 'Studying muonic atoms with advanced numerical solutions of the Dirac-Breit-Darwin equation'*
P-31	*A. N. Gkrepis, 'Derivation of advanced Python code for solving the Dirac-Coulomb-Breit equation in muonic atoms'*

Sponsored by:

Oral Presentations

Determination of the Stopping Power and Range of Ions in Matter by Resonance Methods

A.F. Gurbich, T.L. Bobrovskiy, M.V. Bokhovko, P.S. Prusachenko

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At energies above the Coulomb barrier, the cross section for elastic scattering of light ions from most nuclei has a resonance structure. This structure is observed in backscattering spectra from a thick target, and the position of the corresponding anomalies in the registered energy spectra depends not only on the initial energy of the ion and the resonance energy, but also on the stopping power of the target material. The higher the initial energy of the ion, the longer the range of the ion slowing down in the target until it reaches the resonance energy, i.e. the resonance interaction occurs at a greater depth, which is reflected in the energy spectrum of the scattered ions emitted from the target. Thus, the position of the anomalies observed in the backscattering spectra at a given initial energy of the ions depends on the stopping power. A technique which exploited this feature to determine the dependence of the stopping power on energy is presented. It can be applied to both single element materials and compounds provided that they contain at least one element the elastic scattering cross-section for which has a resonance structure.

The SRIM software [1] appears to be the most popular source of the data for stopping power and range of ions in matter. Meanwhile it has certain deficiencies [2] and the reliability of some SRIM predictions especially for heavy ions is questionable. The experiment to determine Ni ions range in matter consisted in the implantation of nickel ions into samples followed by the determination of the depth profile of the implanted ions by nuclear reaction resonance profiling is presented. It is shown that the extended range of Ni ions predicted by SRIM-2013 is inconsistent with the experimental results.

References

[1] J.F. Ziegler, M.D. Ziegler, J.P. Biersack, SRIM – The stopping and range of ions in matter (2010), Nucl. Instr. Meth. in Phys. Res. **B268,** 1818 (2010).
[2] K. Wittmaack, Misconceptions impairing the validity of the stopping power tables in the SRIM library and suggestions for doing better in the future, Nucl. Instr. Meth. in Phys. Res. **B380**, 57 (2016).

Study of fission products characteristics with the LOHENGRIN spectrometer

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Fission yields are one of the most used observables to describe the fission process. They are also mandatory for nuclear fuel cycle studies or nuclear reactor calculations. A collaboration between CEA, LPSC, and ILL has been working since 2010 on the LOHENGRIN spectrometer to better control the possible experimental biases and systematic uncertainties.

Different setups allow us to study some characteristics of fission products. In this talk, we will highlight the recent results obtained. For instance, mass yields of 235U(nth,f) were measured with high accuracy. A new methodology has been developed in order to better handle the specificity of the LOHENGRIN spectrometer.

Also, a new procedure has been developed to measure independent fission yields for shielded isotopes. For such isotopes, due to their low cumulated yield, their γ signals are very low in comparison to the γ–ray background at the measurement position. Therefore, the ions were collected by implantation of the mass-separated beam into Al foil placed inside a vacuum chamber. This foil was then removed and transferred to a low γ-ray background setup located at LPSC. The procedure is then repeated for different LOHENGRIN settings. The low γ-ray background setup features a considerably improved signal-to-background ratio compared to conventional measurements in the online regime.

Other characteristics of fission products can be studied with the LOHENGRIN spectrometer such as their angular momentum. Usually, fission product angular momentum is studied through prompt γ emission or isomeric ratio measurement. The later observable is of interest because it preserves the initial angular momentum information resulting from the fission process just after the prompt particle emission. Recently experimental campaigns achieved at the ILL showed the kinetic energy dependence of isomeric ratios for numerous nuclei for 235U(nth,f) and 241Pu(nth,f) reactions. A Bayesian assessment of the angular momentum distribution is proposed according to calculations performed with the FIFRELIN code. The similar angular momentum distributions found for both reactions are interpreted with angular momentum generation models.

Global studies of reactions with weakly bound nuclei at sub- and near-barrier energies

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We will present a survey of our comprehensive studies including elastic scattering, breakup and fusion with weakly bound projectiles on light and heavy targets, for determining the energy dependence of the optical potential at sub- and near- barrier energies [1-5]. We would outline the necessity of using global studies for it, and we will close with the description of a global optical potential for ^{7}Be on various targets.

References

[1] A. Pakou *et al*., Phys. Lett. **B 556**, 21(2003).
[2] K. Zerva *et al.,* Eur. Phys. J. **A 48**, 102 (2012).
[3] A. Pakou *et al.,* Eur. Phys. J. **A 58**, 8 (2022).
[4] K. Palli *et al.,* Phy. Rev. C **105**, 044609(2022).
[5] O. Sgouros *et al.,* Phys. Rev. C **106**, 044612 (2022).

Measurement of the ^{235}U(n,f) cross-section using the ^{10}B(n,α) reaction as reference at EAR-2 of n_TOF at CERN: first results

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

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The fission cross section of ^{235}U is widely used as a reference reaction and it is considered a standard at thermal energies and in the energy regions 7.8 to 11 eV and 0.15 to 200 MeV [1], while it is used as a reference reaction in energy regions beyond the standards. However, some discrepancies of the cross-section values have been observed, specifically below 100 keV [2-4]. In this context, new data for the ^{235}U(n,f) reaction can be proven extremely useful, in order to assist in the improvement of the evaluations and even extend the energy region where it is considered a standard.

In this framework, new high accuracy data are available for the fission cross section of ^{235}U using as reference the standard ^{10}B(n, α) reaction. The data were obtained at the latest fission campaign at n_TOF at CERN, using the gaseous Micromegas detectors. The experiment was carried out at the experimental area EAR-2, with the new spallation target installed in 2022.

In this work, the first preliminary results from the data analysis will be presented.

References

[1] A.D. Carlson *et al*., Nucl. Data Sheets **148, 143** (2018)
[2] M. Barbagallo *et al*., Eur. Phys. J. A**49, 156** (2013)
[3] M. Jandel *et al.*, Phys. Rev. Lett. **109,** 202506 (2012)
[4] S. Amaducci *et al.*, Eur. Phys. J. A **55**, 120 (2019)

Production of actinide targets using Solution Combustion Synthesis and the effects after Ion and Neutron irradiation*

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Actinide targets are in great demand due to the importance actinides hold in nuclear science and stockpile stewardship research. These targets are quite challenging to make since they are typically radioactive and rare/low in abundance. We have developed a new procedure in which solution combustion synthesis (SCS) is used in conjunction with electrospray deposition methods in order to produce uniform targets using the least amount of material. Chemically reactive solutions were deposited as layers and were then converted to actinide oxides by simple heat treatment (Figure 1). This method allows the control of the layer thicknesses while it provides excellent uniformity, producing thin (10-500 μg/cm^2) depleted uranium oxide (UO_2) layers on various backings.

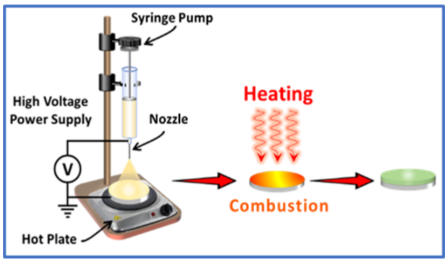

Figure 1: Electrospraying setup and the SCS process

The effects of ion irradiation on the UO_2 targets were investigated with an Ar^{2+} beam produced by the single-ended accelerator (5U) at the Nuclear Science Laboratory at the University of Notre Dame[1,2]. The structural changes that took place and the overall stability of the targets will be reported. Additionally, the effects of neutron irradiation, the robustness and the purity of the targets were investigated using a neutron beam at the Los Alamos National Lab (LANL) LANSCE facility and the DANCE detector array and will be presented here as well.

The newly developed techniques have been applied to other actinides such as americium. Americium is a chemically challenging isotope, thus we initially developed approaches with Eu_2O_3 (targets with thickness ~ 2000 μg/cm^2)[3], as surrogates for $^{243}AmO_2$. The Am targets will be used in a neutron capture cross-section measurement experiment utilizing the new spallation target (MARK IV) that was installed in 2022 at the LANSCE facility.

* This work is supported by the US Department of Energy's (DOE) National Nuclear Security Administration (Grant # NA0004093) and the US National Science Foundation (NSF, PHY-2011890).

References

1. Dede, S. *et al.* Irradiation-induced amorphization of UO2 films prepared by spraying-assisted combustion synthesis. *Appl. Surf. Sci.* **603**, 154437 (2022).
2. Dede, S. *et al.* Irradiation-enhanced Interactions at UO2/Al2O3/Al Interfaces. *J. Phys. Chem. C* (2023) doi:10.1021/acs.jpcc.3c01155.
3. Roach, J. M., *et al*. Combustion synthesis of Eu2O3 nanomaterials with tunable phase composition and morphology. *J. Solid State Chem.* **326**, 124235 (2023).

Study of (n,x) Reactions on Ge isotopes in the Energy Range Between 15.5 and 18.9 MeV Implementing Enriched Ge Targets

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The study of neutron induced reactions on Ge isotopes is of great importance, both for practical applications (dosimetry, nuclear medicine, astrophysical projects, reactor and detector technology), as well as, from a fundamental research point of view. More specifically, the five stable naturally occurring isotopes of Ge (^{70,72,73,74,76}Ge) can produce a plethora of (n,x) reactions, revealing interesting systematics, especially since some residual nuclei are produced in high spin isomeric states, whose decay is heavily dependent on the spin distribution of the continuum phase space and the spins of the respective discrete levels. Accurate cross-section measurements of such reaction channels can act as a very important constraint in statistical model calculations.

In the present work, the cross sections of the ^{70}Ge(n,2n)^{69}Ge, ^{72}Ge(n,p)^{72}Ga, ^{72}Ge(n,α)^{71m}Zn, ^{73}Ge(n,p)^{72}Ga, ^{73}Ge(n,np/d)^{73}Ga, ^{73}Ge(n,nα)^{69}mZn ^{74}Ge(n,α)^{71m}Zn, ^{74}Ge(n,np/d)^{73}Ga and ^{76}Ge(n,2n)^{75}Ge reactions have been experimentally measured via the activation technique, implementing the ^{27}Al(n,α)^{24}Na reference reaction in the energy range of E_n=15.5-18.9 MeV, complementing previous studies by our group [1-2] at lower neutron beam energies. The irradiations were performed at the 5.5 MV Tandem Accelerator Laboratory of N.C.S.R. "Demokritos" and the neutron beam production was achieved via the ^{3}H(d,n)^{4}He reaction. Five isotopically enriched targets of ^{70,72,73,74,76}Ge in the form of GeO_2 pellets, that have been made available by the n_TOF collaboration (CERN), were employed for the measurements of the present work. Most data found in literature implement ^{nat}Ge targets, that require theoretical corrections bearing their own uncertainties, to compensate for the contribution of parasitic channels in the measured yield, stemming from neighbouring isotopes that produce the same residual nucleus as the measured one. This contribution becomes more significant at higher energies. Enriched targets remain unaffected from such parasitic contributions, deeming the cross-section data produced in the energy range of E_n=15.5-18.9 MeV more accurate, and useful for the improvement of theoretical models and future evaluation curves.

References

[1] Gkatis, G., *et al*. (2020). Cross Section Measurements of (n,p) Reactions on Ge Isotopes. *HNPS Advances in Nuclear Physics, 27*, 185-188. doi:http://dx.doi.org/10.12681/hnps.2998
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Angular distribution measurements of neutron elastic scattering by natural carbon

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Carbon is an important material, utilized in a broad spectrum of nuclear technology applications. In nuclear reactors, graphite is used as a moderator and reflector due to its low neutron absorption cross-section, high neutron scattering cross-section, and high thermal conductivity. Additionally, carbon fiber-reinforced materials are considered an attractive choice for use in structural components of next-generation reactors. Therefore, precise neutron data are essential for the design and safe operation of such facilities.

In many laboratories, measurements of the cross section of neutron elastic scattering by carbon are used to monitor the stability of detectors and validate experimental results. It is well suited for this purpose as the cross section is known with an uncertainty of less than 1% up to 4.8 MeV neutron energy. Also, the differential cross section is a standard for neutron energies below 1.8 MeV, but above 2 MeV discrepancies between different evaluations and experimental data have been observed.

New measurements of neutron scattering on ^{nat}C were carried out at the neutron time-of-flight facility GELINA, using a graphite disk of natural isotopic composition. For the detection of the scattered neutrons, the ELISA (ELastic and Inelastic Scattering Array) spectrometer was used. The array consists of a ^{235}U fission chamber for the measurement of the neutron flux, and 32 liquid organic scintillators. The scintillators can separate neutron and photon induced events via pulse-shape analysis. They are placed at eight different scattering angles to simultaneously calculate the differential and the total elastic cross section via numerical quadrature [1-2].

In this presentation, the analysis procedure along with the results for the differential cross section of neutron elastic scattering by ^{nat}C in the energy range from 1 to 8 MeV are presented.

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First Results from the ^{243}Am(n,f) cross-section measurement at the nTOF facility at CERN *

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The ^{243}Am(n,f) reaction is very important both for basic Nuclear Physics and Nuclear Technology. Fission is a dominant reaction mechanism of heavy nuclei and one of the most complicated phenomena of nuclear physics, involving large-scale collective motion with shell and pairing effects. In addition, the design and feasibility studies on the new generation nuclear reactors (such as Accelerator Driven Systems-ADS and Generation IV Fast Neutron Reactors) for the future production of clean and safe nuclear energy, require high-accuracy nuclear data. Among the long-lived minor actinides involved in the nuclear waste, the ^{243}Am isotope ($T_{1/2}$ = 7364y), plays an important role in the radiotoxicity, as it contributes to the production of ^{239}Pu ($T_{1/2}$=24110 y), via α- and subsequent β- decay. However, the available data in literature for the ^{243}Am(n,f) reaction scarce especially in the sub-threshold region, presenting many discrepancies, or poor energy resolution.

For these reasons, a new measurement of the ^{243}Am(n,f) cross section was performed at the n_TOF facility at CERN in order to produce, for the first time, a high-accuracy and high-resolution data set of the ^{243}Am(n,f) reaction, covering the neutron energy range of 10 orders of magnitude from thermal up to hundreds of MeV. The measurement includes Micromegas detectors and especially designed, high purity mono-isotopic ^{243}Am targets, which were produced and characterized at the JRC-Geel in Belgium. In this work, the preparation of the experimental setup, along with some first preliminary results will be presented.

* 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.

Characterization of Diamond Detector Response to Neutron Beams at the NCSR "Demokritos" *

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Diamond is considered as one of the most promising materials for detector construction because of its exceptional properties, particularly when used in difficult environmental conditions. Some of these properties are the high radiation resistance, high thermal conductivity, and low thermal expansion coefficient, but also high stiffness as well as biological and chemical inertia [1]. Diamond detector systems are therefore extensively used in radiation applications, especially in the field of neutron induced reaction research as well as neutron fluence measurements [2]. For in-beam neutron measurements, a novel diamond detector system and related electronics were developed by the CIVIDEC Instrumentation [3], including a single crystalline synthetic diamond sensor (an allotrope of carbon) with 50 μm thickness, manufactured with CVD (Chemical Vapour Deposition) technology. The whole system was tested in different neutron beams to extract the response of the detector [4].

The first measurement was performed at the TANDEM accelerator of the I.N.P.P. of the NCSR "Demokritos", where the diamond detector was tested in monoenergetic neutron beams with different energies. Various quasi-monoenergetic neutron beams were produced via $^{3}H(p,n)$ and $^{3}H(d,n)$ interactions in a TiT target. In this work the preliminary results of this test will be presented and discussed, along with the corresponding simulations which were conducted by using the Geant4 simulation toolkit [5].

* This work is supported by the Basic Research Program PEVE 2021 of the National Technical University of Athens

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Charged particle spectroscopy using a ring-shaped silicon nTD detector: First results on the detector's response using a neutron converter target at n_TOF/CERN.

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Neutron-induced reactions where one of the reaction products is a light-charged particle are of prime importance for fundamental research as well as for energy and medical nuclear physics applications. Nowadays, the nuclear physics community lacks experimental data on threshold reactions across a board energy range. In particular, for several commonly used structural materials of fusion reactors, these data sets are urgently needed.

To address this lack of cross-section measurements within the n_TOF collaboration a novel charged particle detector setup is under development. Within this contribution, the characterization of this setup will be presented.

The detector is manufactured by a silicon CD-shaped wafer segmented on both sides offering accordingly position-sensitive measurements [1]. The silicon wafer has undergone the neutron transmutation doping technique that allows for a very uniform electric field within the wafer volume when the detector is polarized. In this way, pulse shaping techniques can be applied for particle identification, instead of the ΔE/E method. The particles' identification can be achieved due to the different stopping powers of different particles that give rise to different signal shapes [2]. Within this framework, an experimental campaign was scheduled and performed with the major objectives of characterizing the detector's response and reinforcing the neural network of the PSA algorithm. The experimental conditions along with some first experimental results will be presented.

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Measured, Evaluated, and Benchmarked Differential Cross Sections for Proton Elastic Scattering on ^{nat}N in the Energy Range E=3-5 MeV

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Nitrogen and its compounds have a wide range of uses, therefore, it is crucial to accurately determine the corresponding depth profile concentrations, and Ion Beam Analysis (IBA) techniques have been shown to be ideal for this purpose. In particular, the proton elastic backscattering spectroscopy (p-EBS) technique is now widely used for the detection of almost all light elements up to a depth of several microns. The objective to study nitrogen concentrations at large depths, however, is hindered by a number of analytical constraints, the most important of which is the relative lack of several coherent reliable experimental (for example, like the ones presented in [1]) data. Moreover, since they are the most trustworthy, evaluated differential cross sections are greatly desired for the deployment of EBS. These are the results of R-matrix calculations based on several experimental differential cross-section datasets. The online calculator SigmaCalc 2.0 (http://www.sigmacalc.obninsk.ru) provides these evaluated datasets. However, the proton evaluation in the case of nitrogen is currently limited in the energy range between 300 and 3400 keV.

To solve these issues, we first determined the experimental differential cross sections of the ^{nat}N(p,p$_0$) elastic scattering using the relative measurement technique, in the proton beam energy range $E_{p,lab}$=3-5 MeV with a variable step (10 keV in most cases and 20 or 40 keV far away from resonances), at six backscattering detector angles, ranging from 120^o to 170^o (with a 10^o step). The measurements were carried out on N.C.S.R. "Demokritos" in Athens, Greece's recently upgraded 5.5 MV HV TN-11 Van de Graaff Tandem Accelerator. Following the determination of the differential cross-section values, the experimental datasets from the current work, along with all other datasets already present in literature, were studied within the theoretical R-matrix framework, and, following the setting of the appropriate nuclear model parameters, new evaluated differential cross-section datasets have been derived, especially tuned for EBS applications at steep backscattering angles. These were then benchmarked at RUBION, Ruhr University Bochum. The scientific community will soon have access to all of the experimental and analyzed differential cross-section datasets via the IBANDL (https://www-nds.iaea.org/exfor/ibandl.htm) and SigmaCalc 2.0 websites, both in tabulated and graphical formats.

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Constraining the Astrophysical γ Process: Cross Section Measurements of (p,γ) Reactions in Inverse Kinematics

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One of the most fundamental queries in nuclear astrophysics is understanding the mechanisms through which the elements are forged in the stars. For the vast majority of the elements heavier than iron, stellar nucleosynthesis is largely governed by the slow and rapid neutron capture processes. However, a relatively small group of naturally occurring, neutron-deficient isotopes, located in the region between ^{74}Se and ^{196}Hg, the so called *p* nuclei, cannot be formed by either of those processes. These ~30 stable nuclei are believed to be formed in the so called *γ* process from the "burning" of preexisting *r* and *s* process seeds at stellar environments of sufficiently high temperature, where a sequence of photodisintegration reactions can occur. The astrophysical site where such temperature conditions are fulfilled has been a subject of controversy for more than 60 years, and is currently believed to occur in the O/Ne layers of core collapse supernovae, and in thermonuclear supernovae.

Networks of nuclear reactions are simulated under appropriate astrophysical conditions in order to reproduce the *p* nuclei abundances that are observed in nature. However, as experimental cross sections of *γ* process reactions are almost entirely unknown, the related reaction rates are based entirely on Hauser-Feshbach (HF) theoretical calculations and therefore carry large uncertainties. For this purpose the accurate cross section measurement of photodisintegration reactions within the astrophysically relevant Gamow window is of crucial importance. In this talk two such experiments will be presented, namely the total cross section measurement of the ^{82}Kr(p,γ)^{83}Rb and ^{73}As(p,γ)^{74}Se reactions. Specifically the latter reaction is found to be of significant importance to the final abundance of the lightest p-nucleus, ^{74}Se, as the inverse reaction is its main destruction mechanism[1,2]. The experiments took place at Michigan State University using the ReA facility. The ^{82}Kr and ^{73}As beams were directed onto a hydrogen gas cell located in the center of the Summing NaI(Tl) (SuN) detector and the obtained spectra were analyzed using the γ-summing technique. In addition to the total cross section measurement of the particular reaction, statistical properties of the compound nucleus (nuclear level density and γ-ray strength function) can also be extracted. Results from the two experiments along with their comparison to standard statistical model calculations using the NON-SMOKER and TALYS codes will be presented.

* This work was supported by the National Science Foundation, the U.S. Department of Energy, National Nuclear Security Administration and the Department of Energy, Office of Science, Office of Nuclear Physics.

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Multinucleon Transfer Reactions in the ^{70}Zn (15 MeV/nucleon) + ^{64}Ni System: Detailed Studies of the Reaction Mechanism

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Towards the production of nuclei far away from the line of beta stability, except the traditional approaches of fragmentation, fission and fusion reactions, one can produce such rare isotopes by multinucleon transfer and deep-inelastic interactions between heavy ions at energies near and above the Coulomb barrier [1,2]. The present work constitutes one of the few high resolution mass-spectrometric studies in the energy range of 15–25 MeV/nucleon. We obtained high-quality experimental data from a recent experiment with the MAGNEX spectrometer at the INFN-LNS in Catania, Italy [3]. We have then proceeded to develop a systematic approach to reconstruct the atomic number Z of the ejectiles along with their ionic charge states employing measurements of the energy loss, residual energy and time-of-flight [4]. The momentum distributions (p/A), angular distributions and the production cross sections of several multinucleon transfer channels were extracted and studied systematically. Our experimental distributions shown in this contribution are compared with two dynamical models, the Deep-Inelastic Transfer (DIT) model [5] and the Constrained Molecular Dynamics (CoMD) model [6]. Subsequently, the code GEMINI is applied for the de-excitation of the primary fragments [7]. The DIT model, designed to describe the sequential exchange of nucleons, yield an overall fair description of the processes that correspond to nucleon exchange, but is not able to effectively describe parts of the distributions that refer to direct reaction mechanisms. While the microscopic CoMD model calculations indicate that further development is needed, that is already underway. The present work outlines an experimental approach to study peripheral reactions of medium-mass nuclei in the Fermi energy regime and an effort to pave a systematic way toward the efficient production of exotic neutron-rich nuclei.

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Elastic Scattering of $^{8}B+^{90}Zr$ at Sub-barrier Energies

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Elastic scattering measurements for the reaction $^{8}B+^{90}Zr$ at the sub-barrier energy 27.7 MeV (~ 0.9 $V_{C.B.}$) were carried out in a recent experiment, realized at the *TriSol* radioactive beam facility of the University of Notre Dame. This experiment was performed in continuation of our previous work studying ^{8}B on the heavier target ^{208}Pb [1], alongside with breakup measurements for the same reaction. Final goal is the determination of total reaction and breakup cross sections and the deduction of the direct to total cross section ratio. Preliminary experimental data for elastic scattering will be presented and compared with OMP and CDCC calculations. The last making use of the potential extracted from a simultaneous elastic scattering measurements for $^{7}Be+^{90}Zr$ [2, 3].

* This work is supported by the Hellenic Foundation of Research and Innovation

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Nuclear structure investigations in medium–weight isotopes

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This work focuses on the nuclear structure and spectroscopic properties of even-even isotopes of Ytterbium ($^{164\text{-}180}$Yb) and Tungsten ($^{172\text{-}186}$W). This mass region is of significant interest due to its unexplored nature and the presence of intriguing structural phenomena, including deformation, shape changes, and shape coexistence. The present work combines theoretical calculations and experimental measurements to provide insights into the behavior and structure of these nuclei.

The theoretical part of the work involves extensive calculations using different models, including the Interacting Boson Model-1 (IBM-1), to study the energy levels, electric quadrupole moments Q, and electric quadrupole transition probabilities B(E2) for Yb and W isotopes. The results agree with previous experimental measurements and contribute to the knowledge of deformation, shape changes in neutron-rich nuclei.

Experimental measurements were conducted in the National Laboratory IFIN-HH in Romania, focused on the spectroscopic study of Yb and W isotopes using advanced techniques, such as Fast Electronics Scintillators Timing (FEST) and Recoil Distance Doppler Shift (RDDS) methods. These experiments provided valuable data on the energy levels, lifetimes, and decay properties of the excited states in the nuclei. The measurements were performed using ROSPHERE detector array, including HPGe detectors, $LaBr_3$(Ce) scintillators, and particle identification detectors. As a result, the lower limits of the lifetimes for the isotopes ^{172,174,176,178}Yb were determined through the reaction ^{18}O + ^{nat}Yb at 72 MeV beam energy using FEST. In addition, the result for the 6_1^+ in ^{182}W obtained for the first time via the reaction ^{181}Ta(^{11}B, ^{10}Be)^{182}W and the RDDS method at 47 MeV and was found to agree well with earlier measurements.

Nuclear lifetime measurements around Z=50

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Neutron-deficient nuclei in the Z=50 region where the proton shell closes, such as tellurium isotopes (Z=52), have been a subject of both experimental and theoretical studies. Collective phenomena, such us shape-coexistence and shape evolution, are strongly present around the Z=50 shell closure, providing important information on the nuclear structure in this mass regime. A dedicated experimental study of the lifetimes of in Te and Sb isotopes was undertaken at the 9 MV Tandem accelerator at the IFIN-HH in Romania. Beams of ^{11}B at 35 MeV impinged on a ^{nat}Ag target to populate the nuclei of interest. The emitted gamma rays and charged particles were detected by the ROSPHERE and SORCERER arrays. The activation method was used to measure lifetimes of decaying isomeric and ground states in ^{117}Te and ^{115,117}Sb. The present results update existing literature data from half a century ago employing a new reaction mechanism to populate the states of interest along with a more advanced array of detectors.

Fast-timing measurements of nuclear lifetimes in the Z~50 region

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The neutron–deficient region around the Z=50 major shell closure provides fertile grounds for nuclear structure studies, as single–particle degrees of freedom compete with collective phenomena to form several of the observed spectroscopic properties. This work reports on the progress and the preliminary results of a recent experiment performed at IFIN–HH, in Magurele, Romania, focused around the measurement of lifetimes of excited states in neutron–deficient Te isotopes, by means of the Fast Electronic Scintillation Timing (FEST, or fast–timing) technique [1]. A ^{11}B beam of E_{lab} = 35 MeV impinging on a 5 mg/cm^2 ^{nat}Ag target was used to populate excited states in $^{115-120}$Te. The γ rays de-exciting these levels were detected by the ROSPHERE [2] array, in its mixed 15 HPGe + 10 $LaBr_3$(Ce) detector configuration. Additionally, the SORCERER [3] particle detector array was coupled to ROSPHERE, enabling the study of p-γ and p-γ-γ coincident events. The combination of experimental findings and theoretical predictions from several models, including the newly developed proxy-SU(3) [4], is anticipated to offer valuable insights into the dynamic shape evolution of the investigated isotopes. This study focus on a specific area of the nuclear chart where shape coexistence is expected to be present.

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Design and simulations of a linear Paul trap for single-ion spectroscopy

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To understand the key behaviors of the atomic nucleus, tremendous effort over the past decades has been put on ab-initio theoretical models [1], which are able to reproduce experimental data with great accuracy. To better benchmark such models, various observables need to be measured, with one of the most important ones being the nuclear electromagnetic moments and charge radii, both complimentary to each other.

Measurements of these quantities can be obtained using different techniques, but the most successful one has been laser spectroscopy. However, this method can be applied only on beams with low contamination and low kinetic energies, limiting its application to Isotope Separation On-Line (ISOL) facilities or Projectile Fragmentation (PF) ones with a gas cell [2]. Efforts to increase the production limit are ongoing, but the low production yields in the exotic region, along with the lower sensitivity of classic laser spectroscopy techniques, is also a limiting factor.

To overcome the above limitations and extend the measurements, the ions of interest in RIB facilities will be studied in a segmented linear Paul trap, designed and optimized inside SIMION 8.1 [3]. This will substantially increase the laser-ion interaction time, offering higher sensitivity for hyperfine structure precision spectroscopy experiments. Typical ISOLDE beams have been injected, decelerated and captured dynamically, without any buffer gas. Subsequent Doppler laser cooling down to the limit has been performed, with the aim to reduce the Doppler broadening below the natural linewidth. The results indicate that the trapping and cooling schemes can be performed with around 75 % efficiency, in a few 100 ms, paving the way to the study of more exotic species on the edges of the nuclear chart. The configuration of this trap can also be extended for sympathetic cooling of trapped species [4] and/or radiofrequency spectroscopy using forbidden transitions [5]. Construction of the trap setup will begin this autumn, as part of my PhD.

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The ^{88}Zr study at DICER at LANSCE*

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The ^{88}Zr nucleus was recently reported to have the second largest thermal neutron capture cross section [1] and the largest resonance integral [2] across nuclei in the nuclear chart. The studies reported in Refs. [1] and [2] were performed in reactors and therefore lacked energy dependent information which would be useful to understand why ^{88}Zr has such a large thermal capture cross section and resonance integral.

The surprisingly enormous thermal capture cross section could be explained by the presence of a near-thermal resonance, therefore a study was conducted at the Los Alamos Neutron Science Center (LANSCE) neutron time-of-flight facility. A tiny 1 ug liquid sample was fabricated in collaboration with the Isotope Production Facility (IPF) at LANSCE and was installed at the newly commissioned Device for Indirect Capture Experiments on Radionuclides (DICER) [3].

The first exciting results along with the experimental details will be presented.

* This work was funded by the Los Alamos National Laboratory – Laboratory Directed Research and Development, Directed Research (LANL-LDRD-DR)

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Fission-Fragment Mass Spectrometry at the Los Alamos Neutron Science Center Facility*

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Independent fission product yields (FPY), i.e., yields of fission products right after the prompt neutron emission, but before beta decay, are an important piece of data for nuclear fission modeling and applications. Currently, there is a significant deficiency in experimental data for energy-dependent FPYs, even for key reactions in nuclear technology, such as ^{239}Pu(n,f) and ^{235}U(n,f). At the same time, the majority of the available data comes from radiochemical measurements and direct kinematics experiments with limited efficiency, limited resolution, and usually unconstrained systematic uncertainties. To meet the current needs for fidelity data, the Spectrometer for Ion Determination in fission Research (SPIDER) was developed at Los Alamos Neutron Science Center (LANSCE) for measuring FPYs from neutron-induced fission, eventually spanning from thermal up to 20 MeV incident neutron energy. In this presentation, an overview of the SPIDER system and results from the most recent test measurements will be discussed.

* This work is supported by the US Department of Energy through the Los Alamos National Laboratory, Contract No. 89233218CNA00000. (LA-UR-23-28467)

Direct (p,n) Reaction Measurements of Astrophysical Interest Using Radioactive Beams: A Novel Approach with SECAR

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The synthesis of elements beyond iron heavily relies on neutron-induced reactions. Studies indicate that certain key (n,p) reactions, such as ^{56}Ni(n,p)^{56}Co and ^{64}Ge(n,p)^{64}Ga, can accelerate the neutrino-p process (νp-process), contributing to element creation between Ni and Sn during type II Supernovae. This process occurs in regions with a slight excess of protons within the ν-driven wind of core-collapse supernovae, involving a sequence of proton-capture and (n,p) reactions. The limited neutron abundance essential for (n,p) reactions originates from anti-neutrino captures on free protons.

The new approach introduced in this study involves investigating (n,p) reactions through the measurement of the reverse (p,n) reactions in inverse kinematics, using a heavy radioactive beam directed at a hydrogen target, and applying the detailed balance principle [1]. Reaction recoils are separated from the unreacted beam and detected using SECAR (SEparator for CApture Reactions) [2] at FRIB (Facility for Rare Isotope Beams). Measuring (p,n) reactions poses challenges due to the almost identical masses of recoils and unreacted projectiles. Nonetheless, an appropriate separation is achieved by employing neutron tagging alongside SECAR. In a recent experiment, the direct measurement of the ^{58}Fe(p,n)^{58}Co reaction in inverse kinematics, at 3.65 MeV/u was successfully performed by detecting emitted neutrons at the target location and ^{58}Co ions at the end of the SECAR beamline. Neutron detection utilized a combination of organic liquid and plastic scintillators, while for heavy ions, the SECAR's ΔE-E detection system consisting of an Ionization Chamber (IC) and a Double sided Silicon Strip Detector (DSSD) was employed. This direct measurement of the ^{58}Fe(p,n)^{58}Co reaction complements earlier results obtained via activation techniques and is expected to enhance cross-section data. It also opens the path for further (p,n) reaction measurements with significant astrophysical importance using radioactive beams. The first results and experimental details of this technique will be presented.

* This project is supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Award Number DE-SC0014285 and DE-SC0022538 DOE grant. The SECAR project is supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Award Number DE-SC0014384, and by the National Science Foundation under Grant No. PHY-1624942. Additional support for this work comes from National Science Foundation Grants No. PHY-1430152 (Joint Institute for Nuclear Astrophysics and JINA-CEE) and PHY-1565546 (NSCL).

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Extraction of the Nuclear Level Density of the neutron rich isotopes ^{68}Cu & ^{65}Ni using the LANSCE/WNR neutron beams and the evaporation technique

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Stellar evolution involves nuclear reactions occurring at energies much lower than the Coulomb barrier, highlighting the importance of neutron-induced reactions in the synthesis of elements, especially those heavier than iron. To extract nuclear level densities (NLD) of unstable isotopes, crucial for accurate reaction rate calculations, we can employ neutron-induced reactions (i.e. (n,a) and (n,p)), using the evaporation technique[1,2,3].

To probe NLD in the Ni region, cross-section measurements for the ^{68}Zn(n,p)^{68}Cu and ^{68}Zn(n,a)^{65}Ni reactions were carried out at the WNR facility at LANSCE. A neutron beam spanning from 0.1 to 100 MeV was impinging a highly enriched ^{68}Zn target placed at the center of LENZ[4,5,6] (Low Energy neutron-induced Charged-particle(Z)) chamber. For the detection of the reaction products, annular S1 DSSD telescopes both upstream and downstream of the target were used. Discrimination between protons and alpha particles was achieved using the pulse shape discrimination technique. The experimental data obtained in the energy range of 10 to 13 MeV will be utilized for extracting level densities of the neutron-rich isotopes of ^{68}Cu and ^{65}Ni employing the evaporation technique.

The fundamental concept of the evaporation technique lies in the fact that the differential cross-section for the emission of a particle from a compound nucleus is directly proportional to the appropriate transmission coefficient and NLD. Consequently, the detailed shape of the particle spectrum is determined by the energy dependence of the level density. By comparing the experimental spectra to those calculated using the Hauser-Feshbach theory and adjusting the theory parameters to reproduce the experimental ones, we can further enhance the experimental level density.

In this talk, we present details about the experimental setup, analysis procedures, and preliminary results for the measurement of ^{68}Zn(n,a)^{65}Ni and ^{68}Zn(n,p)^{68}Cu reaction cross-sections, along with the extraction of NLD for ^{68}Cu and ^{65}Ni.

* This work is supported by DOE funding by grant DE-SC0022538

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Nuclear Astrophysics at NEAR/n_TOF: Data analysis of first MACS measurements

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The "NEAR" activation station at the n_TOF facility of CERN is a new experimental area delivered in 2021 and dedicated mainly to measurements of astrophysical interest [1]. This activation station is located at a distance of ~3m from the facility's neutron source. The neutron energies at NEAR span a wide spectrum, from thermal up to the GeV region. With the use of suitable filters and moderators, this wide spectrum can be narrowed down and shaped into a Maxwell-Boltzmann distribution, which would allow a direct, integral measurement of Maxwellian-averaged cross sections [2].

During the 2022 and 2023 n_TOF experimental campaigns, some first neutron capture experiments using boron carbide filters took place, as a feasibility study for the shaping of the NEAR neutron energy distribution. In this work, these experiments will be presented together with the data analysis procedure and some first results.

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Lattice-site location of Mn in Mn-rich Sb_2Te_3 topological insulators using MeV ion channeling

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In the present contribution we will highlight some recent research activities performed at the Tandem Laboratory at Uppsala University. The main focus will be the implementation of MeV ions to a topological insulator system. Topological insulators [1] are a new class of quantum materials that are insulators in the bulk while they support the flow of electrons on the surface. The idea to combine ferromagnetism with topological insulators, in order to acquire a quantum anomalous Hall effect, has stimulated great interest in condensed matter physics and materials science with potential for applications in high-precision metrology, low-power-consumption spintronic devices, and topological quantum computation. This combination can be achieved by introducing magnetic dopants in topological insulators. Indeed, introducing Mn in Sb_2Te_3 in the stoichiometry of $MnSb_2Te_4$ led to ferromagnetic topological insulators [2]. Even though $MnSb_2Te_4$ films were thoroughly characterized by high-resolution Scanning Transmission Electron Microscopy (STEM) and X-ray Diffraction (XRD), experimental determination of the atomic site occupancy of the excess Mn in the crystal remains challenging.

We investigate the system of $Mn_xSb_2T_{3+x}$ by implementing simultaneous channeling Rutherford Backscattering Spectrometry (RBS) and channeling Particle Induced X-ray Emission (PIXE) experiments to shed further light on the lattice site of Mn in the crystal. Measurements were performed at the 5-MV 15SDH-2 Pelletron Tandem accelerator at Uppsala University using a primary ion beam of 2 MeV He^+. The goniometer in the scattering chamber can be tilted and rotated in two directions without moving the point of interaction with the primary ion beam allowing access to different crystal orientations. The under-study samples were two $Mn_xSb_2Te_{3+x}$ films with 200 nm nominal thickness epitaxially grown on BaF_2 (111) substrates with different amounts of incorporated Mn. We determined the concentration of Mn in the samples to be $Mn_{1.06}Sb_2Te_{4.06}$ and $Mn_{2.6}Sb_2Te_{5.6}$ by standard RBS measurements and confirmed it with standard PIXE measurements. We obtained extensive channeling maps for Sb and Te in different crystal orientations for both samples as well as high resolution angular scans for Sb and Te and for Mn. We directly identified the Mn lattice site occupancy to be substitutional by comparing the width and the depth of the channeling minima of Sb and Te to Mn.

Additionally, we will briefly show recent fundamental activities using keV ions transmitted through self-supporting, single crystalline membranes [3] and a recent study of in-situ annealing of self-reporting Cr_2AlC.

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Systematic study of ^{3}He – induced reactions and elastic scattering on light isotopes for applications in Ion Beam Analysis

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The interactions of the plasma fuel with the Plasma Facing Components (**PFC**s) that line the inside of a reactor lead to deposition and erosion phenomena, the study of which is of paramount importance in the field of fusion research. These studies, however, require the ability to identify specific isotopes and determine their depth profiles in various matrices, a task in which Ion Beam Analysis techniques excel at.

Regarding Ion Beam Analysis applications, ^{3}He beams offer higher q-values in addition to greater mass resolution compared to proton and deuteron beams. Moreover, in contrast to deuteron beams, their use is not accompanied by high neutron fluxes, that raise radiation safety concerns. These advantages ensure not only higher accuracy and sensitivity of the measurement but also a safer operation. The main obstacle in the use of ^{3}He beams is the availability of reliable differential cross-ection data. As a result, the International Atomic Energy Agency has requested the implementation of dedicated differential cross-section measurements for ^{3}He-induced reactions and elastic scattering on light isotopes for energies and detection angles suitable for IBA applications [1].

In this presentation, the ongoing work of the RUBION accelerator facility in Bochum, Germany, for the implementation of such cross-section measurements is presented. Details regarding the experimental setup and the data analysis are also provided. The results of various measurements are presented and discussed in detail and whenever possible compared to other datasets available in the literature. Moreover, the experiments were accompanied by benchmarking measurements in order to check the validity of the obtained cross sections. These results are also presented and discussed in detail. All of the cross-section datasets will be publicly available through the IBANDL online library [2]. Finally, in the future, the experimental datasets will be included in analytical calculations using the R-Matrix theoretical framework with the aim of creating the first evaluated cross-ection datasets regarding ^{3}He-induced reactions and elastic scattering.

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Shape/phase transitions and shape coexistence in even-even nuclei

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Shape/phase transitions have been observed in certain regions of the nuclear chart. Shape coexistence is also known to occur in various regions of the nuclear chart, forming islands [1,2]. The interrelation between these two concepts is considered in the regions around (N=90, Z=60), (N=60, Z=40), (N=40, Z=34), in which shape coexistence due to proton-induced neutron particle-hole excitations [3,4] is related to a first-order shape/phase transition from spherical to deformed shapes [5].

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The multi-messenger nuclear physics of neutron stars

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One of the most important problems of nuclear physics and astrophysics is the internal structure of compact objects, including mainly neutron stars, boson stars, white dwarfs and compact dark objects as well. The internal structure of all the above objects became subject of a thorough study by researchers from different branches of physics including nuclear physics, astrophysics, particle physics, general relativity and thermodynamics. Problems such as: a) the composition and properties of dense nuclear matter; b) the existence of exotic phases involving strangeness, such as hyperons, kaon or pion condensates, and deconfined quark matter; c) the possibility of dark matter being absorbed inside them and d) the existence of compact dark objects, all of them today are included in the researcher's agenda. On the other hand, the accelerated improvement of the research, concerning the study of gravitational waves, has opened important perspectives to study the above theoretical predictions. We expect that in the near future, with the help of the detection of gravitational waves from events associated with compact objects (binary neutron star merger, various instability modes, etc.) and other observations including mainly the X-ray radiation and gamma-rays burst, the theoretical predictions and speculations will be able to be tested, providing us answers to some of the most fundamental problems of physics. In the present talk, I will briefly consider and present some of the most important and relevant problems and to highlight how they can be addressed from the theoretical and observational point of view.

Covariant density functional description of shape phase transitions and shape coexistence in heavy nuclei

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The phenomena of shape phase transitions and shape coexistence in even-even heavy nuclei are analysed within the covariant density functional framework. Spectroscopic observables that characterize low-lying collective excitations associated with order parameters are computed using the corresponding generalized microscopic collective Hamiltonians with deformations as dynamical collective coordinates. The parameters of the Hamiltonians are determined by relativistic Hartree-Bogoliubov calculations based on the energy density functional DD-PC1, and a finite-range pairing interaction.

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Probing new physics with nuclear recoil data from COHERENT*

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The observation of coherent elastic neutrino nucleus scattering (CEvNS) has opened the window to several physics opportunities. We discuss a vast array of implications, including tests of the Standard Model and new physics probes. In our analyses we consider experimental uncertainties associated to the efficiency as well as the timing distribution of neutrino fluxes, making our results rather robust. Specifically, we update previous measurements of the weak mixing angle and the neutron root mean square charge radius for CsI and argon. We also revisit the constraints on new physics scenarios including neutrino nonstandard interactions and neutrino electromagnetic properties [1]. We finally explore the possibility of producing of a new MeV-scale Dark Fermion (DF) at the COHERENT experiment via the upscattering process of neutrinos off the nuclei and the electrons of the detector material [2].

* This work was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "3rd Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers" (Project Number: 7036).

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Study of quarkyonic matter and applications in neutron stars

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In the present work we study extensively the so-called quarkyonic matter, a hybrid state between hadrons and quarks, which believed to exist in the interior of neutron stars. This is a very recent idea which believed to give a consistent way to explain the phase transition from hadronic matter to quark matter, in the region between the outer and the inner core inside a neutron star. In particular, we use two theoretical models.

The first one is a model containing neutrons which interact each other via a potential that depends on the baryon number density and non-interacting up and down quarks. The second one, also consists of neutrons, up and down quarks which interact each other via a momentum depended potential. For each model we extract an equation of state and we compare them with existing ones from other theoretical models. Next we calculated the speed of sound to test the correctness of our equations of state and whether they obey or violate causality. Moreover, we construct a mass-radius diagram for several central densities and we compare it with already existing diagrams from observational data but also from other theoretical models and we also calculate some additional useful parameters of the neutron star such as tidal deformability and compactness of the star. Our objective is to impose some additional constrains both on the microscopic parameters of the nuclear equation of state as well as on the bulk properties of the neutron star for future studies Finally, we intent to compare with observational data resulting from the detection of gravitational waves, from modern detection devices such as LIGO and VIRGO, but also from the detection of electromagnetic signals we receive from various neutron stars.

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Supramassive compact objects with neutron star and dark matter origins

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Till today, the nature of dark matter remains elusive despite all our efforts. This missing matter of the universe has not been observed by the already operating dark matter direct-detection experiments, but we can infer its gravitational effects. Galaxies and clusters of galaxies are most likely to contain dark matter trapped to their gravitational field. This leads us to the natural assumption that compact objects might contain dark matter too. Among the compact objects exist in galaxies, neutron stars considered as natural laboratories, where theories can be tested, and observational data can be received. Thus, many models of dark matter they have proposed it's presence in those stars. By employing the two fluid model, we discovered a stable area in the M R diagram of a celestial formation consisting of neutron and dark matter that is substantial in size and vast in dimensions. This formation spans hundreds of kilometers in diameter and possesses a mass equivalent to 30 or more times that of our sun. To elucidate, this entity resembles an enormous celestial body of dark matter, with a neutron star at its core This implies that a supermassive stellar compact entity can exist without encountering any issues of stability and without undergoing a collapse into a black hole. In any case, the present theoretical prediction can, if combined with corresponding observations, shed light on the existence of dark matter and even more on its basic properties.

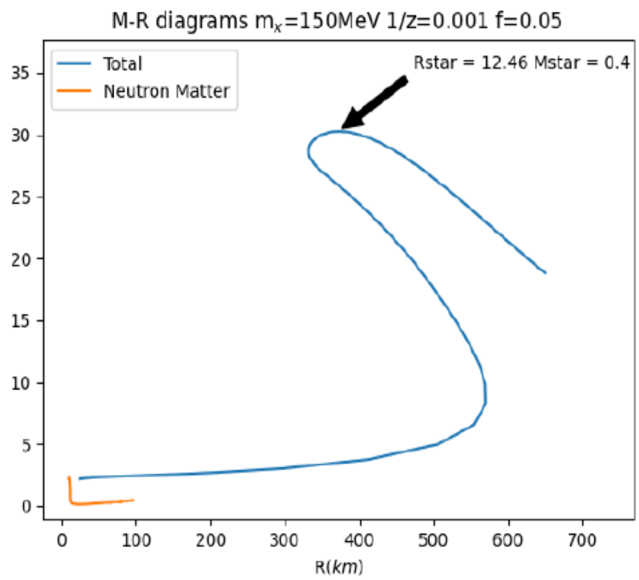

Figure 1: The M-R diagram for a pure neutron star and a neutron star with dark matter admixture just for comparison and for specific mass and self-interaction for the dark matter candidate.

Signatures of hadron-quark phase transition through the r-mode instability in twin stars

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The observation of two compact stars with equal mass but different radius (twin stars) would be a strong indication of hadron-quark phase transition in dense nuclear matter. In this work we examine the differences that appear in the r-mode instability windows and evolution of twin stars in order to investigate the possibility of identifying them through the future detection of gravitational waves. We find that two stars with an identical mass and fairly similar temperature and rotational frequency may behave differently with respect to the r-modes. Hence, the future possible detection of gravitational radiation due to unstable r-modes from a star appearing in the stable region of the frequency-temperature plane (which will be determined by the absence of gravitation wave emission from existing and future pulsar observations) would be a clear sign for the existence of twin stars. In addition, we examine the compatibility of current data from low mass x-ray binaries with the predictions from hybrid equations of state that support the existence of third stable branch of compact objects. We find that, depending on the energy density jump and the crust elasticity, hybrid equations of state may serve as a viable solution for the explanation of existing observations.

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Large Volume Spherical Proportional Counter for Dark Matter Detection From the Φ=60cm Sphere to the Φ=3m Sphere and the New Design of the Sensors

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The spherical proportional counter is a gaseous detector with many applications.

A special spherical detector designed, for the dark matter detection in underground laboratories. The dark matter detection is based on the measurement of the very low energy recoils which produced from the scattering of the WIMPs on the gas nucleus in the sphere. The main specifications of those detectors are the following: a) possibility of very low energy recoils detection, from several keV up to single electrons, b) good energy resolution, c) large volume and high gas pressure, to increase the response of the detector, d) stability and e) very low background with the use of special materials with low radioactivity.

New multi – anode sensors developed, named "achinos", to cover the above demands. In this work is presented also the first results of the 60cm sphere, the new 140cm detector and the plan for the large 3m spherical detector.

Fundamental X-ray studies using Synchrotron Radiation

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The fostering of XRF applications in various disciplines, presenting high relevance with technological, societal, cultural and policy making needs, calls for further advances not only with respect to improved equipment performance and capabilities, but also to our basic knowledge regarding the so-called X-ray Fundamental Parameters (FP). Even though many compilations exhibit internal consistency, resulted by dedicated atomic model calculations or through careful evaluations of available experimental data, there is in fact a lack of systematic and consistent experimental data associated with low relative uncertainties (≤5%).

The experimental method of choice for the determination of different X-ray FPs is the selective photoionization method using tunable synchrotron radiation of highly spectral quality delivered by appropriate double crystal monochromators and high order suppressor optics. Apart from the optimum target related requirements (ultra-thin targets of certified areal density and homogeneity, deposited ideally on ultra-thin substrates of high purity), there are further key instrumental needs to minimize associated experimental uncertainties, such as the monitoring of the beam intensity with high precision and accuracy and the use of energy dispersive detector with known intrinsic characteristics, energy response and reliable dead time correction.

The present contribution aims to highlight FP studies performed at the XRF beamline of Elettra Sincrotrone Trieste equipped with the IAEAXspe instrument [1]. The measurements were performed on specific elements (Sn, Sb, Dy and Re) confirming the onset (Re) or cut-off (Sn) of certain atomic Coster-Kronig decay channels that alter systematics of certain FPs over the periodic table [2, 3].

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A modular custom-built Macro-XRF spectrometer for Heritage Science

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Scanning XRF spectrometry (Macro-XRF) is nowadays a widely established imaging technique for Heritage Science applications. By means of raster scanning, it allows the non-destructive elemental mapping of large, mostly flat, surfaces generating images of elements distribution, well perceived by non-expert curators, archaeologists, conservators, and art-historians. The MA-XRF images allow a firmly and enhanced characterization of the elemental composition of ancient artifacts and historical artworks/materials, providing useful insights into the manufacturing process, but also to surface corrosion products and processes [1, 2].

This contribution presents the development and characterization of a modular portable MA-XRF spectrometer. The system consists of a transmission 12W Rh anode X-ray tube, a silicon drift detector (SSD) of a 150 mm^2 active area and a laser proximity sensor integrated on a three-axis motorized platform (75cm x 50cm x 25cm). The proximity sensor allows reproducible alignment of the spectrometer head and control of the measurement geometry. The setup is controlled by an in-house developed LabView program. Modular optics, including a polycapillary X-ray lens and diaphragms of variable diameters provide a tunable sized exciting beam from ~0.1mm to several mm's, optimized for different applications.

Monte Carlo simulations using the PenRed [3] code, an extensible and parallel Monte-Carlo framework for radiation transport based on PENELOPE and X-ray tracing code [4] were applied to characterize the excitation spectrum in terms of energy distribution, spatial resolution, and divergence in various optic-to-sample distances. The first applications of the MA-XRF spectrometer highlight its advanced analytical capabilities and performance.

*This project is funded by the project PROTEAS, which is co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship, and Innovation, under the call RESEARCH – CREATE - INNOVATE (project code: T2EDK-02428, NSFR MIS-5069984)

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Reactor neutrino detection with the NEWS-G3 experiment

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The NEWS-G3 experiment is planning to use a Spherical Proportional Counter (SPC) for the measurement of coherent elastic neutrino-nucleus scattering at a nuclear reactor. The detector consists of a low-radioactivity copper sphere enclosed in a compact shield made of layers of copper, polyethylene and lead. The shield is equipped with an active muon veto made of twelve plastic scintillation panels. A choice of low atomic mass gaseous targets and the SPC's low energy threshold provides high sensitivity to low-energy recoil. A novel multi anode sensor, placed at the center of the SPC, allows for operations at high pressures.

The NEWS-G3 shielding is installed at Queen's University. Preliminary measurements for the estimation of background levels, veto efficiency and livetime are ongoing. The detector is planned to operate in argon or neon-based mixtures, in a 60 cm diameter low radioactivity copper sphere, which is planned to arrive at Queen's by the end of 2023. Current measurements at Queen's are focused at exploring the detector response at high pressures in argon and neon mixtures in a 30 cm diameter stainless-steel sphere.

Fe^{+} ion irradiation of Fe-10at%Cr alloys at 300 ^{o}C: magnetic and structural effects

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Ferritic – martensitic steels, based on Fe-Cr model alloys are the leading candidate structural materials for fusion power plants. Particularly, alloys containing approximately 10 at% Cr have demonstrated the most favorable characteristics for such applications. Thus, the understanding of the influence of neutron irradiation at elevated temperatures on Fe-Cr alloys is of paramount importance for the development of radiation resistant materials. Self – ion irradiation can imitate the radiation damage caused by energetic neutrons that are present in a fusion environment.

In the current study Fe-10at%Cr films with thickness of 70 nm were irradiated at 300 °C with 490 keV Fe^{+} ions to doses ranging from 0.5 to 20 displacements per atom (dpa). Polarized Neutron Reflectivity technique was employed for the determination of the depth resolved magnetization. An increase in the magnetization was found as a function of dose which was attributed to Cr agglomeration and/or segregation in the Fe-Cr matrix. This was further supported by Atom Probe Tomography measurements that showed the formation of Cr clusters co-located with oxygen after irradiation. The determined Cr concentration is reduced with the increase of dose, and for doses above 4 dpa, it stabilizes to the asymptotic value of (8.4±0.3) at%.

Acknowledgements: This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under Grant Agreements No. 633053 and No 101052200. The views and opinions expressed herein do not necessarily reflect those of the European Commission. The funding from the Greek National Programme for the Controlled Thermonuclear Fusion is acknowledged. Experiments at the ISIS Neutron and Muon Source were supported by a beamtime allocation from the Science and Technology Facilities Council. The use of the Ion Beam Center facilities at Helmholtz-Zentrum Dresden-Rossendorf is acknowledged. The research used UKAEA's Materials Research Facility, which has been funded by and is part of the UK's National Nuclear User Facility and Henry Royce Institute for Advanced Materials.

Positron Annihilation Study of Neutron-Induced Defects in Single Crystal Tungsten: Effects of Irradiation Dose and Temperature

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Fusion energy presents a promising and sustainable solution to address the increasing global energy demands, offering the potential for abundant and environmentally friendly energy production. However, the safe and prolonged operation of fusion reactors necessitates the utilization of plasma facing materials capable of withstanding the challenges posed by high-energy neutron irradiation, intense heat fluxes, the impact of highly energetic particles, and cyclic stress loading. Tungsten is a prime candidate plasma facing material for future fusion reactors, due to its exceptional properties, including its high melting point, high thermal conductivity, low coefficient of thermal expansion, high sputtering threshold energy, low tritium retention, and minimal neutron activation characteristics.

The aim of this work is to investigate the evolution of the open volume defects of neutron irradiated W(100) single crystal samples as a function of the irradiation temperature and dose using Positron Annihilation Lifetime Spectroscopy (PALS). The materials were irradiated at the BR2 research reactor, located at SCK-CEN, Mol, Belgium at four distinct irradiation doses ranging from 0.12 to 0.85 displacements per atom (dpa) and at four irradiation temperatures, spanning from 600 to 1200 °C.

The obtained PALS results demonstrate that neutron irradiation induces the creation of dislocations as well as voids exceeding approximately 1 nm in size across all irradiation temperatures and doses. Moreover, the average size of the voids increases as the irradiation temperature rises. By the application of the two traps model, it is found that with increasing irradiation temperature, both the dislocation number density and the void length density (the product of the void size with the void number density) decrease for all the irradiation doses, which indicates that the increased irradiation temperature contributes to the dissolution of open volume defects in the material. The dislocation number density does not exhibit a significant dependence on the irradiation dose in the range of 0.12 - 0.85 dpa. However, the void length density increases as the irradiation dose increases for the irradiation temperatures of 800 and 900 °C, whereas after irradiation at the temperatures of 600 and 1200 °C no considerable dependence on dose is observed.

Acknowledgements: This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme *2014-2018, 2019-2020 and 2021-2025 under grant agreement Nos 633053* and 101052200. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them. The author also acknowledges support of this work by the project “NCSRD – INRASTES research activities in the framework of the national RIS3" (MIS 5002559) which is implemented under the “Action for the Strategic Development on the Research and Technological Sector”, funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).

Proton irradiation studies of Uranium Nitride (UN) and (U,Zr)N composite fuels *

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The effect of proton (H^+) irradiation on uranium mononitride (UN) and UN composite fuel with 10 at.% ZrN (UN10at%ZrN) was examined. UN and $(U_{0.9},Zr_{0.1})N$ powders were fabricated at KTH Nuclear Fuel Lab and the consolidation of the powders was performed through Spark Plasma Sintering (SPS). Protons of 2 MeV with fluences of 10^{17}, 10^{18}, 10^{19} and 10^{20} ions/cm^2 causing a peak dose of 0.1, 1, 10 and 100 dpa respectively, were accelerated towards the fabricated samples in order to investigate the evolution of the irradiated microstructure. Stopping and Range of Ions in Matter (SRIM) calculations were performed to determine the displacements per atom and the associated depth of the highest damage, for each fluence.

X-Ray diffraction (XRD) was used to identify the chemical composition and the lattice parameter of each pellet. Inert gas diffusion technique revealed the low presence of 135 ppm of oxygen impurity in UN powder, which is the lower oxygen presence reported in UN powder made by the hydriding-nitriding-denitrding process [1]. Based on scanning electron microscopy (SEM), deterioration of the samples surface was observed, as the dose increased. Proton implantation due to the irradiation, formed point defects in the material which led to spatial expansion and through diffusion led to significant levels of swelling [2] and eventually to the cracking of the pellets at the highest dose of 100 dpa, as Figure 1 shows. Blisters and craters (Figure 2) appear to surround the cracked region, which might originate from the significant levels of hydrogen implantation within the samples. The swelling of the irradiated regions were further investigated by atomic force microscopy (AFM).

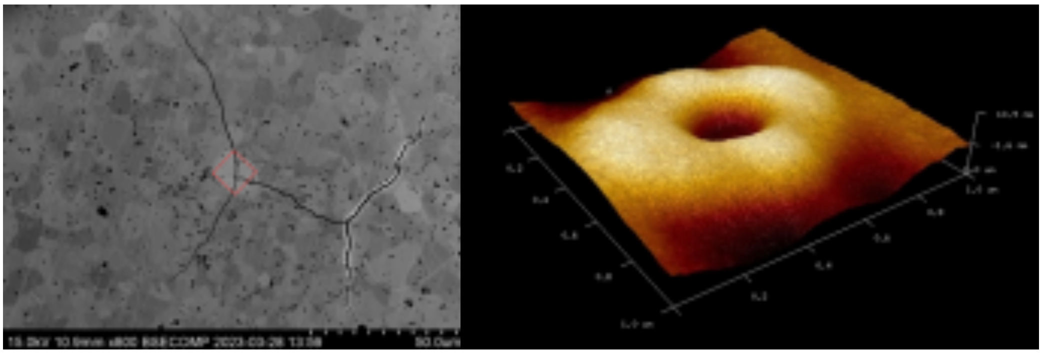

Figure 1: Irradiated spot of 100 dpa in UN, using BSE electrons for 10x10 μm^2 irradiated area.

Figure 2: 3D profile of a crater in UN surface after the irradiation, through AFM.

* This work is supported by the SSF Swedish Foundation for Strategic Research

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A study on the wall effect of Spherical Proportional Counter for long range particle detection

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The Spherical Proportional Counter is a large-volume gaseous detector that finds application in many fields, like α, β, γ radiation detection, neutrino detection and Dark Matter research.

When a reaction happens close to the detector wall it is possible for the produced particles to hit the wall and lose energy. This is known as the wall effect and it leads to wrong calculations of the incident particle energy. It depends on the particles' range and the detector characteristics, such as its size and the gas pressure.

In this work, a study has been done in order to quantify the wall effect for the SPC, for any application. We used neutron beams, which cover the total volume of the sphere and interact with the gas nuclei, giving several reactions. The presented data derive from simulations on GEANT4 and are in agreement with the experimental data from neutron beams of the TANDEM Accelerator Laboratory, NCSR Demokritos.

A comparative analysis of Cs-137 soil migration over a thirty six years study period (1987-2023) : Experimental measurements vs. compartment model predictions

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In the aftermath of the Chernobyl disaster, a designated plot spanning roughly 1000 m² within the University Farm of Aristotle University of Thessaloniki in Northern Greece was repurposed as a testing site for conducting radioecological measurements. This site served as a controlled environment for the assessment of time dependence Cs-137 distribution in the soil. The monitoring period extended from 1987 to 2023, during which soil samples were systematically collected in increments of 5 cm thickness, essentially forming distinct soil layers (0-5 cm),(5-10 cm) up to (25-30 cm). Throughout the 36-year measurement period, no agricultural activities took place in the field. The sole human intervention consisted of cutting the surface grasses without disrupting the underlying soil. It is important to mention that one of the authors of the present study actively participated in all the measurements conducted at the site throughout this extended period from 1987 to 2023.The mean total deposition of Cs-137 in the area of all measurements performed during the last 36 years and backdated to the time of the Chernobyl accident, was determined to be 22 ± 6.4 kBq m^{-2}. In addition, based on the initial and most recent profiles taken at the site, one year and 37 years following the Chernobyl nuclear accident, the deposition of Cs -137 (backdated at the time of the Chernobyl nuclear accident) was determined to be 27.3 ± 3 kBq m^{-2} and 20.2 ± 2 kBq m^{-2}, respectively. Notably, the agreement between these two results is deemed satisfactory, particularly considering the substantial 36-year gap between the two measurements. Vertical migration of Cs-137 in soil is a very slow process. The mean vertical migration velocity is estimated at 0.12 cm y^{-1}. In the long-term evolution study of Cs-137 distribution in soil over a period of approximately 36 years, we were able to investigate the time dependence of the fractional contribution of each soil layer (e.g., 0-5 cm, 5-10 cm, 10-15 cm, etc.) to the total deposition of Cs-137 (0-30 cm). The results are compared with model predictions where layers of soil are represented by compartments. The model assumes that the transfer rates between adjacent compartments are equal. Overall, a relatively good agreement between the measured fractional contributions with the predictions of the compartment model is observed. This suggests that the compartment model employed in this study is capable of providing a satisfactory description of the observed migration of Cs-137 in soil over a long period (1987-2023). On the other hand, the use of a second compartment model with increasing transfer rates between consecutive soil layers did not align with the observed outcomes. This suggests that diffusion may not be the primary migration mechanism over the long-term period of our study, which spans 36 years. Perhaps other migration mechanisms, apart from diffusion, play a significant role in the migration of Cs-137 in the soil.

Inventory of natural radionuclides in the Greek mineral springs

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The use of mineral/thermomineral springs for therapeutical purposes and their beneficial effects are dated back to the antiquity. During the last decades, spa tourism called also medical tourism has become, due its social and economic expansions, a major part of the international tourist market. After the discovery of the phenomenon of radioactivity, it was found that certain springs are characterized by elevated concentrations of natural radionuclides especially of ^{222}Rn. Measurements of radionuclides in water of selected springs, including hot springs, are reported since 1905 [1, 2] to the present. Concerning the Greek territory, the first studies of thermal springs were carried out in the 1920s and 1930s [3, 4, 5] while as studies on radionuclide concentrations and the respective radiological impact have been carried out until our days [6, 7, 8].

In this study, measurements of ^{222}Rn, ^{226}Ra and ^{238}U in Greek spa waters are presented, for the dry and wet period of the year including the radiological assessment in some cases. The concentrations ranges are 0,50±0,18 – 8.574± 238 Bq/l for ^{222}Rn, <0,1 -7,0±0,2 Bq/l for ^{226}Ra and 0,07±0,05 – 0,9±0,1 for ^{238}U. In all cases, the springs are located near the seashore and in temperate places in mainland Greece. For this reason, they have been established over the centuries as places of "therapeutical tourism". It is emphasized that the measurements and the assessment of radiological exposure are varied widely, while the estimated risk is closed associated with the prevailing conditions of exposure.

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Radioactivity mapping of beach sand by mobile in situ gamma-ray spectrometry *

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A new method for prompt radioactivity mapping of beach sand is under investigation. It is based on mobile in situ gamma-ray spectrometry exploiting low- and medium-resolution portable scintillator systems. Spectra of very short acquisition time (20s) are obtained by a mobile unit (man or vehicle) along transects on the beach sand. The statistic of each spectrum is extremely low for individual analysis however, the spatial resolution of each measurement is preserved high (a few meters). The distribution of the total counting rate is used to classify the spectra, according to quartiles, into four classes (high, low, medium-high and medium-low). For each class, the spectra are combined into one of a total acquisition time high enough for spectrometric analyses. Laboratory HPGe measurements and simulation studies were used to calculate the efficiency of selected photo-peak energies. The first maps obtained by the mobile method are in very good agreement with those obtained by grid sampling and laboratory analyses. Critical aspects under further investigation regard the varied physical parameters of the beach sand (density, water content, porosity) and the complicated detection geometry both of them strongly related to the efficiency.

Figure: ^{214}Bi (1760 keV) mapping of Legrena beach, south Attica, Greece

Joint IAEA/EEAE Regional Intercomparison Exercise on Radioanalytical Analysis of NORM Samples.

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Radionuclides of a natural origin of the Uranium and Thorium series and the Potassium-40 are present in most materials that are commonly referred to as Naturally Occurring Radioactive Materials (NORMs). In some materials, activity concentrations of radionuclides of natural origin are significantly elevated to the extent that regulatory control is required for radiation protection purposes. The International Basic Safety Standards (BSS) set the radiation protection requirements for regulators, operators, and workers. The characterization of NORM is the key element for an efficient and effective implementation of the BSS.

In order to assess MS's technical capability, infrastructure, and resources in radioanalytical analysis of NORM Samples, IAEA, in collaboration with EEAE, organized a Regional Intercomparison Exercise under the Europe Technical Cooperation Regional Project RER/9/155. The aim of this exercise was to assess the capabilities of the Member States in the region to implement appropriate radioanalytical techniques (i.e., gamma spectrometry, alpha spectrometry, liquid scintillation counting) for the radiological characterization of NORM in line with the IAEA safety standards, particularly GSG-7, with a primary focus on radiation protection of workers in industrial processes involving NORM.

The Intercomparison Exercise was conducted between July 2022 and November 2022. Each participant was requested to provide results on the activity concentration of naturally occurring radionuclides in two types of samples: (i) a phosphate ore sample; (ii) a phosphogypsum sample by using radioanalytical techniques (i.e., γ-spectrometry, α-spectrometry, liquid scintillation). The results were evaluated in terms of accuracy and precision on the basis of the estimated assigned value and uncertainty in accordance with ISO 13528:2022.

Within the framework of this work, the preparation of samples, the analysis techniques followed, the statistical analysis of the results performed, and the conclusions derived are presented.

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Atmospheric Dispersion Software Intercomparison Exercise and Sensitivity of Results

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The Greek Atomic Energy Commission (EEAE) is the national regulatory authority, competent for the control, regulation, and supervision in the fields of nuclear energy, nuclear technology, radiological and nuclear safety, and radiation protection. Within its mandate is to assess emergencies in or out of Greece, which may entail radiological risk for the country. To this end, studies based on atmospheric dispersion software, like JRodos, are performed [1]. To validate the performance of the software, EEAE recently participated in a JRodos intercomparison exercise. The exercise was conducted within the Rodos User Group (RUG), and was based on a hypothetical release from a nuclear icebreaker in Danish coastal waters.

This work describes the performance of EEAE within this exercise, and further evaluates its results on the basis of their sensitivity in parameters such as the atmospheric dispersion models used, and the height of release. To this end, three atmospheric dispersion models: RIMPUFF [2], LASAT [3], and DIPCOT [4], were applied. Their results were compared in different timesteps in terms of the effective gamma-dose rate at the height of 1 meter. The release was also simulated at different heights to establish the sensitivity of each model to that parameter.

It was found that results tend to differentiate immediately after the release due to the models' different approaches. However, all models yield similar results after the first hours of the release. Each model also exhibited a different sensitivity to the height parameter, which was quantified.

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αSPECT: Adaptation of existing radon detectors to deep-sea operation *

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RAMONES [1], a project funded by the EU H2020 FET Proactive program, aims to develop prototype instruments for continuous and *in situ* measurements of radioactivity, both natural and artificial, in the marine environment. These instruments will be deployed on a stationary benthic laboratory or on autonomous underwater gliders (AUG). Among the naturally occurring radioactive materials (NORM), radon and its isotopes ^{222}Rn and ^{220}Rn, being the only gaseous products, have a significant role due to their unique transport properties and common chemical characteristics within the respective decay chains of uranium and thorium. Continuous monitoring of radon emissions has diverse applications in geosciences, including the potential for earthquake precursors and their association with changes in volcanic activity [2]. In this work, we report on the development, testing, and characterization of a one-of-a kind and innovative alpha radiation spectrometer known as αSPECT. This instrument, specifically designed for operation in the deep sea, will be hosted on the benthic laboratory. The detection principle of αSPECT relies on electrostatic precipitation [3], where singly charged radon progenies are collected onto silicon detectors [4] where the subsequent alpha decays are measured. To ensure the suitability of αSPECT for deep-sea environments, the detector design is adapted to commercial cylindrical enclosures capable of withstanding harsh marine conditions. Through the deployment of αSPECT, we anticipate gaining insight into deep-sea geochemical processes related to radon emission and circulation. This includes the investigation of sediment-water interactions, water volume dynamics, and properties of submarine hydrothermal vents. Currently, αSPECT is undergoing development, and initial testing is scheduled to commence in the near future.

* This work is supported by European Union under Horizon 2020 FET Proactive Programme via grant agreement No. 101017808

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Validation and Testing of Novel Underwater Sensors at the Hydrothermal Vent Field of Milos*

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The need to perform continuous, *in situ* measurements of radioactivity in the marine environment is a long-standing problem at a global scale. The EU H2020 RAMONES [1] project (Radioactivity Monitoring in Ocean Ecosystems) has made significant progress to overcome existing drawbacks due to the harsh conditions in the deep ocean environments and provide innovative solutions to meet these needs. A class of novel radiation instruments combined with robotic vehicles, allowing for radioactivity measurements at the most remote and harsh marine environments have been developed, characterized, and tested. The mobile γ-spectrometers ("γ-Sniffers") equip autonomously moving gliders, allowing for surveys in the water column. *In situ* field test measurements have been recently performed in the island of Milos, where its strong hydrothermal vent activity acts as a natural laboratory for testing the RAMONES instrumentation in realistic conditions. Validation of the instruments was additionally performed with high-resolution spectroscopy of coastal samples, while the extracted data now feed a specially designed Risk Information System. The results allowed for the evaluation of the instruments under realistic environmental conditions and their optimization before the final deployment and testing. In the present paper, an overview of these activities will be reported.

* This work receives funding from European Union under Horizon 2020 FET Proactive Programme RAMONES via grant agreement No. 101017808

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Radioactivity in building materials used in Lesvos, Greece *

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According to Imani et al. (2021) the majority of people spend 80% of their time inside buildings. It is known that some building materials, such as granite, brick, gypsum, marble and others, contain low levels of naturally-occurring radioactivity due to the presence of radium, uranium and thorium. Depending of the amount of these naturally-occurring elements present on the building materials, they may cause small increases in radiation levels or/and may increase the quantity of radioactive radon (gas) indoors. It is important to take into consideration the daily exposure of population to small amounts of radiation from natural sources such as radioactive materials. Thus, in this work, samples of building materials originating from the island of Lesvos, as well as building materials of global origin that are used extensively in the local community of Lesvos were collected and investigated. The activity concentrations of naturally-occurring radioactivity were studied by the γ-ray spectrometry, utilizing a high-purity germanium (HPGe) detector. Total absorbed dose rates were also calculated and ranged from 1 $nGy \cdot h^{-1}$ to 220 $nGy \cdot h^{-1}$. The building stone samples originating from Lesvos exhibited up to five times higher values than the expected ones for Greece (39 $nGy \cdot h^{-1}$) and the world average (51 $nGy \cdot h^{-1}$). The other studied building materials were characterized by low values of radioactive dose rates, well below those measured in Greece. Finally, the annual absorbed dose (1 mSv) and the activity concentration index proposed by European Commission (2013/59/EURATOM) and IAEA (2019), accordingly, were also calculated and confirmed that some stones of Lesvos Island used as building material, exceed the recommended values and must be further investigated.

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Triplet pairing in neutron matter

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The presence of superfluidity in neutron star interiors can affect the cooling of neutron stars in intricate ways, enhancing certain mechanisms and suppressing others. Model calculations employing realistic nuclear potentials in Bardeen-Cooper-Schrieffer theory generally suggest the development of a $^3P_2$-$^3F_2$ pairing gap, and therefore the presence of superfluidity in dense neutron star matter. Improved models that go beyond conventional mean-field calculations by including polarization effects suggest a suppression of the triplet gap. We have evaluated the pairing interaction by summing the “parquet" Feynman diagrams which include both ladder and ring diagrams systematically, plus a set of important non-parquet diagrams, making this the most comprehensive diagram-based approach presently available. Our results suggest a radical suppression of the $^3P_2$–$^3F_2$ triplet pairing gap and an enhancement of $^3P_0$ pairing.

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Open problems in conventional and exotic muon physics: Predictions of numerical solutions of fundamental differential equations*

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Recently, appreciably sensitive experiments operating in frontier muon facilities at J-PARC in Tokio, PSI in Switzerland, Fermilab in USA, RCNP in Osaka, etc., provide ultra-high-precision measurements in muon physics for open problems in muon-nucleus processes and purely leptonic atomic systems [1]. A plethora of such processes are well analyzed and described by theories falling within (SM) and beyond the Standard Model (BSM) of the electroweak interactions and they constitute promising tests of the quantum electrodynamics (QED) and the BSM physical theories. Up to the present, for example, the muon-nucleus experiments (ordinary muon capture on nuclei [2,3], muon hyperfine spectroscopy [1], muonic-atoms [4], etc.) played essential role in understanding atomic, nuclear and particle physics.

Our main aim is to provide systematic predictions coming out of accurate numerical solutions of the fundamental differential equations (Dirac-Coulomb-Breit, Dirac-Breit-Darwin, etc.) entering the description of structure and reactions appearing in muonic atoms (nuclear muon capture [2,3], muon to e^- (or to e^+) conversion in nuclei [1], etc.) as well as in exotic purely leptonic atoms, i.e. Muonium (μ^+, e^-), Muonium ion (μ^+, e^-e^-), etc. [4,5], promising tests of QED and BSM theories (e.g. testing of fundamental physical laws as the lepton number conservation in experiments searching for Muonium to anti-Muonium transition) [1].

* This work is financially supported by: "The Association for Advancement of Research on Open Problems in Nuclear Physics & Particle Physics (OPRA Association)", Tel Aviv, Israel.

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A global description of the $^{18}O+^{48}Ti$ collision within the NUMEN project *

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A multi-channel approach analysis of the $^{18}O+^{48}Ti$ collision at the energy of 275 MeV was performed under the NUMEN [1] and NURE [2] experimental campaigns with the aim of investigating the complete reaction network potentially involved in the $^{48}Ti \rightarrow ^{48}Ca$ double charge exchange (DCE) transition. The ^{48}Ti nucleus was used as target since it is the daughter nucleus of ^{48}Ca sought out in the neutrino-less double beta ($0\nu\beta\beta$) decay [3] and the study of DCE together with other competing nuclear reaction channels is important to constrain theories on the nuclear matrix elements for this elusive process [4]. Among the nuclear reactions of interest, the study of one- and two- nucleon transfer reactions under the same experimental conditions as the more suppressed DCE one provides the appropriate constraints on the theoretical description of the reaction mechanism via a coherent set the experimental data. Into this context, angular distribution measurements for all the available reaction channels in the $^{18}O+^{48}Ti$ collision were pursued at the MAGNEX facility [5] of INFN-LNS in Catania. An overview of the analysis of elastic scattering [6], one- and two- nucleon transfer reactions [7-9] will be presented, while preliminary results on the analysis of the DCE reaction will be also discussed.

* This project has received financial support from the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Programme (NURE – Grant agreement No. 714625)

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Recent results in the study of the ^{20}Ne + ^{130}Te collision within the NUMEN project and future perspectives *

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The NUMEN project [1-2] aims to investigate specific heavy–ion double charge exchange (DCE) reactions in order to provide experimentally data driven information about nuclear matrix elements (NMEs) of interest in the context of neutrinoless double beta decay (0νββ). Into this framework, the ^{20}Ne + ^{130}Te system was experimentally investigated in a multi-channel approach by measuring the complete net of reaction channels, namely DCE [3], single charge exchange, elastic and inelastic scattering [4], one– and two–nucleon transfer reactions, characterized by the same initial state interaction. The goal of such a study is to fully characterize the properties of the nuclear wavefunctions entering in the 0νββ decay NMEs. The relevant experimental campaign was carried out at INFN – Laboratori Nazionali del Sud (LNS) in Catania using the Superconducting Cyclotron to accelerate the beams and the MAGNEX magnetic spectrometer [5] to detect the reaction ejectiles. The experimental challenges and the obtained results for the ^{20}Ne + ^{130}Te collision will be presented and discussed. A deeper investigation of the ^{130}Te nucleus as well as all the nuclei which are candidates for 0νββ decay is foreseen within the next phase of NUMEN. To this extent, the Research and Development activity relevant to the facility upgrade will be also discussed [6].

* This work has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (NURE – Grant agreement no. 714625) and the European Union's Horizon Europe research and innovation programme (EURO-LABS – Grant agreement no. 101057511).

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Colour-Flavour Locked Quark Stars in light of the Compact Object in HESS J1731-347 and the GW190814 Event

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The central compact object within HESS J1731-347 [1] possesses unique mass and radius properties that renders it a compelling candidate for a self-bound star. In this presentation, we depict our findings corresponding to the examination of the capability of quark stars composed of colour superconducting quark matter to explain the latter object by using its marginalised posterior distribution and imposing it as a constraint on the relevant parameter space.

Namely, we investigate quark matter for Nf=2,3 in the colour-superconducting phase, incorporating pQCD corrections, and derive their properties accordingly. The utilised thermodynamic potential of this work possesses an MIT bag model formalism with the parameters being established as flavour-and-density-independent. In this instance, we conclude the favour of the 3-flavour over the 2-flavour colour superconducting quark matter and we isolate our interest on the former, without neglecting the possible favour of the latter in a different framework. The parameter space is further confined due to the additional requirement for a high maximum mass (MTOV≥2.6 M), accounting for GW190814's secondary companion [2].

The progression, as well as the results of our work, is significantly affected by a further highlighted study regarding colour-flavour locked quark matter in respect to the speed of sound and the trace anomaly, the latter of which was proposed as a measure of conformality [3]. We conclude that it is possible for colour-flavour locked quark stars to reach high masses without violating the conformal bound or the trace anomaly bound 〈〉 B≥0 , provided that the quartic coefficient 4 (a crucial parameter accounting for pQCD corrections in the matter's thermodynamic potential) does not exceed an upper limit which depends on the established MTOV. For MTOV=2.6 M, we find that the limit reads 4≤0.594. Lastly, a final investigation takes place on the agreement of colour-flavour locked quark stars with additional astrophysical objects including the GW170817 and GW190425 events, followed by a relevant discussion and concluding remarks.

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Advancements in Nuclear Engineering and Nuclear Materials: Insights from Sweden's SUNRISE Centre and Initiatives on Public Acceptance *

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This talk presents the latest advancements in nuclear engineering and nuclear materials science, focusing on the notable developments taking place in Sweden. Specifically, we delve into the ground-breaking work done within SUNRISE (Sustainable Nuclear Energy Research in Sweden) Centre [1]. The Centre's primary focus encompasses design, safety analysis, materials development, and qualification for a lead-cooled fast neutron reactor for research purposes, aimed for construction in Oskarshamn, Sweden. Collaborating partners from KTH Royal Institute of Technology, LTU Luleå University of Technology, and UU Uppsala University combine their expertise to drive the project's success. This interdisciplinary endeavor comprises cutting-edge research, emphasizing the development of reactor designs [2], innovative materials testing and characterization [3], and Uranium Nitride (UN) fuel qualification for the proposed reactor.

Furthermore, we will explore the significance of working on public acceptance of nuclear power. To this end, I will introduce my YouTube channel, "Elina Charatsidou - Your Friendly Nuclear Physicist [4]" which endeavours to make nuclear science and engineering accessible to the public through educational online content. I will show and discuss unprecedented statistics obtained from over a year of work around public acceptance and demonstrate innovative ways to alleviate and combat the misconceptions that surround the nuclear field.

By combining insights from the SUNRISE project and efforts to bridge the gap between scientific knowledge and public perception, this talk aims to showcase the advancements in nuclear engineering and material science in Sweden. Moreover, it emphasizes the importance of informed decisions and discussions regarding sustainable nuclear energy solutions, ultimately contributing to the public acceptance of nuclear power.

* This work is supported by SSF (Swedish Foundation for Strategic Research)

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Poster Presentations

Flux determination for the 18 MeV Neutron Beam at NCSR "DEMOKRITOS" using the multiple foil activation method

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Following the upgrade of the TANDEM Accelerator at NCSR "DEMOKRITOS", the determination of the new neutron flux was necessary for further neutron induced experiments. The ^{3}H(d,n)^{4}He reaction is one of the main reactions which are used for the production of neutrons in the energy region from ~15-20 MeV. A Ti-tritiated target is used, consisting of a 2.1 mg/cm^2 Ti-T layer on a 1 mm thick Cu backing.

The aim of the present work was the investigation of the energy dependence of the neutron flux at 18 MeV, via the multiple foil activation technique in combination with the SAND II unfolding code. For this reason, the reference reactions ^{197}Au(n,2n)^{196}Au, ^{27}Al(n,α)^{24}Na, ^{197}Au(n,γ)^{198}Au, ^{59}Co(n,α)^{56}Mn, ^{115}In(n,n′)^{115m}In, ^{56}Fe(n,p)^{56}Mn, ^{48}Ti(n,p)^{48}Sc, ^{93}Nb(n,2n)^{92m}Nb and ^{58}Ni(n,2n)^{57}Ni were used. The assembly of the reference foils was placed at approximately 1.7 cm from the tritium target and was irradiated for 8 hours. The fluctuation of the neutron beam flux was monitored by a BF3 detector located at approximately 3m from the neutron source. The activity of the irradiated foils was measured by two HPGe detectors of 80% efficiency. The gamma-ray self-absorption and the estimation of the neutron flux variation through the foils were calculated by Monte Carlo simulations implementing the MCNP code. The saturated activities of the irradiated foils were used to deduce the experimental unfolded energy spectrum of the neutron flux at 18 MeV with the SAND II code.

An Improved Technique for Monitoring Radon Progeny in Ambient Air

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Ambient air concentration fluctuation of radon progeny, especially short-lived ^{214}Pb and ^{214}Bi, has been widely studied during the past decades [1] [2] [3], with increasing interest towards the investigation of possible correlation with atmospheric parameters and various environmental processes [4] [5] [6] [7].

Within this context and for almost 40 years, ^{214}Bi activity in ambient air has been systematically monitored at the Nuclear Engineering Laboratory of the National Technical University of Athens and efforts have been made to use elevated ^{214}Bi activity as an earthquake precursory signal [8]. However, the measuring technique demonstrated various shortcomings, such as low signal-to-noise ratio and calibration challenges due to the temperature sensitivity of the detector system.

Currently, a new approach has been implemented; the measuring system was replaced and several new techniques have been implemented. Namely, measures were taken to reduce background radiation and enhance the signal, while the collected spectra are corrected for any drift with the use of a ^{40}K source. At present, measurements are conducted on a regular basis (Figure 1), whereas new methodologies to further enhance the signal are examined. When concluded, this study will hopefully contribute to the ongoing investigation of radon progeny fluctuations in atmospheric air.

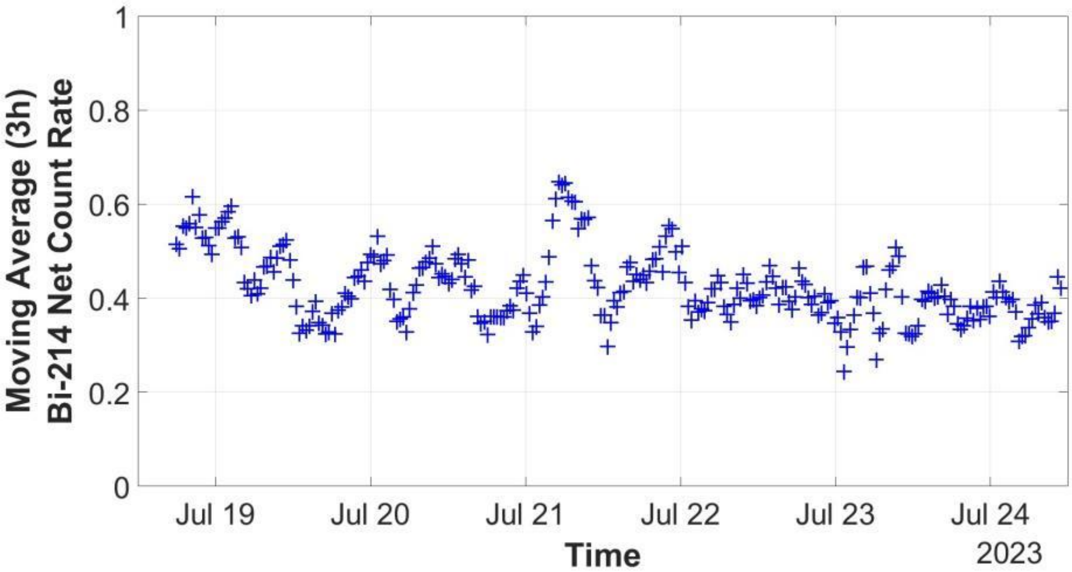

Figure 1: Moving average over 3 hours (6 points) of ^{214}Bi 609keV photons count rate.

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Cross Section Measurements and Theoretical Study of the ^{174,176}Hf(n,2n)^{173,175}Hf Reactions

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Experimental cross section measurements were carried out for the reactions ^{174}Hf(n,2n)^{173}Hf, ^{176}Hf(n,2n)^{175}Hf and ^{180}Hf(n,n'γ)^{180m}Hf using the activation technique. The neutron beam at energies 15.8 MeV and 17.7 MeV was produced via the ^{3}H(d,n)^{4}He reaction at the 5.5 MeV Tandem Van de Graaf accelerator laboratory of NCSR "Demokritos". Thin foils of natural Hf were used, while reference foils of Al and Au were positioned at the front and back of the Hf target for the determination of the neutron flux at the target position. The irradiations were continuous for ~7-9 hours, leading to a total neutron fluence of 10^{10}-10^{11} n/cm^2 and a BF_3 detector was used for monitoring the neutron flux during the irradiations. After the end of each irradiation, the activity of the Hf target and the reference foils was measured off-line by three HPGe detectors. The ^{176}Hf(n,2n)^{175}Hf reaction has been corrected for the contribution of the ^{177}Hf(n,3n)^{175}Hf in the case of 17.7 MeV. A Cd target was employed in the irradiation with 15.8 MeV neutrons to study the contribution of parasitic low energy neutrons, which accompany the main neutron beam. Statistical model calculations based on the Hauser-Feshbach theory have also been performed using the EMPIRE 3.2.3 code. The predictions have been compared with the data of the present work as well as with data from literature.

A comparative study of γ-ray spectrometers in various applications

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The present work focuses on the extensive study of various types of γ-radiation spectrometers from the pool of instruments in the Nuclear Physics Lab at the University of Athens. More specifically, two high purity germanium (HPGe) detectors, one NaI scintillation detector and three CdZnTe (CZT) detectors have been used to carry out measurements with standard calibration sources (^{152}Eu, ^{137}Cs and ^{22}Na) and reference volume samples to extract their operational characteristics, i.e. efficiency and energy resolution. In addition, a set of small-size CZT detectors were studied in terms of their angular response and operation in quasi-realistic aqueous environment.

The comparison results are multi-faceted. All detectors were found to have efficiency very close to the manufacturer values, with two exceptions. The older HPGe detector and a new CZT detector showed a considerably low energy resolution than their nominal values. For the former it can be attributed to the prolonged period of inactivity of the detector, while the latter requires further investigation. The angular response of the CZT detectors is closely connected to the internal geometry of the crystals, which was confirmed via X-ray CT scans. Attenuation of radiation through different layers of water between the source and the detector, as well as the response of the detectors immersed in aqueous solutions of ^{40}K were additionally studied.

Acknowledgments
This work is partially supported by the RAMONES which receives funding from the European Union under Horizon 2020 FET Proactive Programme via grant agreement No. 101017808

High resolution gamma-ray spectrometry of environmental samples at MERL, HCMR

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Marine Environmental Radioactivity Laboratory (MERL) was established at the Hellenic Centre for Marine Research (HCMR) before 15 years and since then is a member of national and international networks (XENOKRATIS, ALMERA and NILNET) providing reliable and timely analysis of radionuclides activity concentrations in environmental samples. During these years, a great number of radioactivity measurements of various matrixes (i.e., water, soil, beach sand, sediment, phytoplankton) from different aquatic environments (i.e., estuaries, lagoons, lakes, coastal zone, ocean, deep sea) and regions (i.e., Mediterranean Sea, Black Sea, the Gulf) via high resolution gamma-ray spectrometry have been performed [1-5]. Here, we demonstrate the main processes applied in order to achieve optimum quantification of the gamma-spectrometry of sediment and water samples combing measurements of various reference sources with semi-empirical numerical methods for the efficiency calibration, along with Monte Carlo simulation technique and appropriate efficiency transfer corrections, while the results are validated, and quality control is implemented by evaluating the lab's performance in the frame of international intercomparison exercise.

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Detailed Study of Multinucleon Transfer Mechanisms in ^{86}Kr + ^{64}Ni at 15 MeV/nucleon

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The production of exotic nuclei is a topic of great interest in the nuclear community. Multinucleon transfer (MNT) and deep inelastic transfer in the Fermi energy domain are processes that can effectively produce these nuclei [1,2].

This work focuses on the detailed study of the reaction mechanisms of multinucleon transfer on peripheral collisions between an ^{86}Kr beam at 15 MeV/nucleon and a target of ^{64}Ni. This is possible via the thorough study of the momentum distributions of reaction channels that produce various projectile-like fragments from neutron rich to neutron deficient. The experimental data of this reaction were obtained with Momentum Achromat Recoil Separator (MARS) at Texas A&M University in a previous work of our group [3]. In the present work, two models were employed to simulate the dynamical part of this reaction. The phenomenological Deep Inelastic Transfer model (DIT) [4] and the microscopic Constrained Molecular Dynamics model (CoMD) [5]. Both were followed by the GEMINI model [6] for the de-excitation of the initial excited projectile-like fragments.

In conjunction with our recent work [7-9], the study of the momentum distributions proves to be a useful tool in shedding light on the reaction mechanisms of peripheral reactions on the Fermi energy regime and the production of exotic nuclei.

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A study of natural radioactivity in urban parks

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Urban parks are typically undisturbed natural locations inside metropolitan areas attracting human recreation activities. In the present work, the main focus is to study the radioactivity levels in urban parks of the metropolitan areas of Athens, Barcelona and Bucharest in an attempt to establish a baseline of the overall environmental load and the associated contribution to background radiation dose levels. 25 soil samples were collected, prepared, and measured with high-resolution gamma spectroscopy at the γSPEC station of the University of Athens. Specific activities for five naturally occurring (^{40}K, ^{214}Pb, ^{208}Tl, ^{212}Pb and ^{214}Bi) and one artificial radioisotope (^{137}Cs) were deduced. The results are correlated to the level of human intervention in the parks, but also show that traces of ^{137}Cs from the Chernobyl fallout are still present in the most undisturbed soils reaching values up to 86±4 Bq/kg. All data have been used to populate a GIS-based informational database, featuring various layers of storyboards and metadata.

Microdosimetric Modelling of Neutron Capture Therapy Effectiveness *

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Ionizing radiation deposits energy in discrete packages distributed non-uniformly throughout the irradiated volume, thus the relative biological effectiveness depends on the lineal energy, y, spectrum. Neutron capture therapy (NCT) is a binary therapeutic modality for the treatment of malignant tumors. This binary treatment modality is based on neutron capture in nuclides with a high capture cross-section. Such exposures result in highly inhomogeneous energy depositions at the microscopic level in the irradiated matter, due to the emission of short-range secondary particles. Due to stochasticity, the average imparted energy per unit mass is inadequate for the prediction of the end-biological effect. Currently, emphasis is given in the physics of the accelerator-based NCT treatments and the synthesis and testing of the optimum ^{10}B and ^{157}Gd carrier compounds.

Monte Carlo code MCNP 6.1 was used to predict the energy deposition at microscopic level for simulating *in vitro* NCT studies. Simulations were carried out for spherical biological water targets, 10 μm in diameter loaded with either 1000 ppm ^{nat}B (200 ppm ^{10}B) or ^{nat}Gd (156 ppm ^{157}Gd), suspended in vials containing either pure water or solutions with capturing agents of identical concentration. Simulations were performed with mono-energetic neutron beams 0.025 to 14.2 MeV in energy. The estimated microdosimetric spectra, were used to calculate the quantities yF, yD and kf.

The simulation outcome depends on the used effective cross section libraries and physics models. ENDF/B-VII.1 and the TENDL-2017 libraries and INCL4/ABLA and Bertini models were tested using published experimental data as benchmark. More specifically, the simulation outputs were compared with the experimentally assessed response of a spherical proportional counter that simulated a tissue equivalent site, 1 μm in diameter, irradiated with 13.9 MeV neutrons. The methodology, as developed, was applied to study the microdistribution spectra in terms of *yd(y)* for the prediction of the biological response of cells irradiated under *in vitro* conditions.

Signatures of Clustering and Cluster Transfer in Peripheral Collisions of ^{40}Ar on ^{64}Ni at 15 MeV/nucleon

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Nucleonic matter behaves as a homogeneous quantum (Fermi) liquid [1]. However, finite nuclei transiently behave as clusters of protons and neutrons. Cluster structures may be observed when the excitation energy is close to the corresponding decay threshold [1,2]. At present, there is a renewed interest in clustering phenomena, both experimental and theoretical [2,3]. While the origin of nuclear clustering stems from the effective nuclear interaction, the detailed mechanism of clustering still remains elusive.

In this work, we studied the momentum distributions of projectile-like fragments from the reaction of an ^{40}Ar beam with a ^{64}Ni target at 15 MeV/nucleon. The original experimental data were obtained in previous works of our group with the MARS spectrometer at the Cyclotron Institute of Texas A&M University [4,5]. Here, we focused our attention to the products that correspond to the pick-up or removal of light clusters (d, t, ^{3}He and ^{4}He).

As a first step in our study, we compared the experimental momentum distributions with calculations performed with the Deep Inelastic Transfer model (DIT) [6] and the Constrained Molecular Dynamics model (CoMD) [7] followed by the de-excitation code GEMINI [8]. The calculations appear to describe a good part of the experimental distributions but are unable to fully describe the quasielastic part. Tentatively, we ascribe this disagreement to a contribution of a direct cluster transfer from the target to the projectile (or vice versa).

We think that peripheral collisions of heavy ions offer the proper conditions (i.e., gentle excitation of the reaction partners) so that clustering may develop, and cluster transfer may be favoured. We plan to investigate in detail the possibility of direct transfer of clusters in this reaction and other reactions studied by our group [5]. Comparing our experimental momentum distributions to appropriate reaction models, as we indicated above, we hope to gain valuable insight into the mechanism of clustering and cluster transfer in peripheral collisions in the Fermi energy regime.

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Detailed Studies of Multinucleon Transfer in ^{40}Ar (15 MeV/nucleon) + ^{64}Ni via High-Resolution Studies of Momentum Distributions

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Multinucleon transfer (MNT) reactions have been extensively used in recent years as an effective tool to move further toward the neutron-rich side of the chart of nuclides. The efficient production of these exotic nuclides is currently at the epicenter of the research interest in facilities around the world. The current contribution focuses on our efforts to systematically study the reaction mechanism of the reaction of an ^{40}Ar beam at 15 MeV/nucleon with a ^{64}Ni target through a detailed analysis of momentum distributions of various reaction channels. The experimental data presented in this work were obtained with the MARS spectrometer at the Cyclotron Institute of Texas A&M University [1]. The experimental distributions are compared with two dynamical models, the Deep-Inelastic Transfer (DIT) model [2] and the Constrained Molecular Dynamics (CoMD) model [3], followed by the deexcitation code GEMINI [4].

The observable of momentum per nucleon (p/A), namely the velocity of the particles, is in fact a measure of the energy dissipation that takes place through the interaction of the target projectile binary system. It holds valuable information on the possible reaction mechanism that leads to the production of the fragments of interest. The general feature of the momentum distributions is the presence of two main regions, namely a quasielastic narrow peak that corresponds to direct processes and a broader region (located in lower values of p/A) that corresponds to more dissipative mechanisms. The comparison between the models and the experimental data through the study of the momentum distributions, as hinted by continued efforts of our group [5-7], is providing an insight toward understanding the complexities of the reactions in the Fermi energy regime (15-25 MeV/nucleon).

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Neutron Induced Reactions on ^{203}Tl at 15.7MeV, 16.0MeV and 18.0MeV

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The aim of the present work is to study the potential channels that result from the interaction of ^{203}Tl with neutrons by bombarding a natural TlCl pellet target. The 5.5 MV Tandem Van de Graff accelerator laboratory of NCSR "Demokritos" used the ^{3}H(d,n)^{4}He process to produce the monoenergetic neutron beam at 15.7MeV, 16.0MeV, and 18.0MeV. The measurements of cross section were based on the activation technique, with respect to the ^{197}Au(n,2n)^{196}Au and ^{27}Al(n,α)^{24}Na reference reactions. After the end of the irradiations, the induced activity in the target and reference foils was measured by γ-ray spectroscopy, using High Purity Germanium detectors (HPGe). This work constitutes a continuation of a previous work of our group with measurements at 16.4, 18.9 and 19.3 MeV, in order to cover the high energy range of neutron beams that can be produced at NCSR "Demokritos" [1,2].

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Neutron Dosimetry at HK-1 beam line of LVR-15 reactor for Biomedical Sample Irradiations *

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Dosimetric calculations were performed for the interpretation of the results of in vitro irradiation experiments of cell cultures at the HK-1 thermal neutron beamline of the LVR-15 research reactor in Řež, Czech Republic. Monte Carlo simulations of neutron irradiated well-type vials containing solutions of ^{nat}Gd or ^{nat}B were carried out to calculate the energy deposition from each particle type produced by thermal neutron capture reactions in ^{10}B and ^{157}Gd for each solution, respectively. Moreover, the geometry of a single cell as target was simulated to predict microdosimetric spectra for different Gd and B solution distributions in the volume surrounding the target cell and calculate neutron fluence to Kerma factors. Although the calculations apply to Gd nuclei, it is assumed that Gd was supplied to the cells in a chelated form to avoid toxicity. Special attention was given to the Auger electrons from Gd. The results of the study support in vitro thermal neutron irradiation experiments aiming to test new boron and gadolinium carriers for neutron capture therapy.

* This work was done in the framework of the FRINGE project (https://www.fringe-fetopen.eu/), which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 828922.
The presented results were obtained using the CICRR infrastructure, which is financially supported by the Ministry of Education, Youth and Sports - project LM2023041.

Study and Validation of Differential Cross Sections for Deuteron-Induced Reactions in ^{13}C, Suitable for NRA

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Since carbon is present in almost everything we study and is primarily made up of the isotope ^{12}C, small dynamic changes in any near surface carbon layer can be better observed by artificially introducing the relatively uncommon ^{13}C isotope, which has the same chemical and physical behavior as ^{12}C. One may quantify changes in the carbon depth profile concentration in several matrices, ranging from biological samples to cultural heritage objects, by using stable isotope tracing with ^{13}C. Nuclear Reaction Analysis (NRA), an Ion Beam Analysis (IBA) technique, has proven to be particularly useful for this purpose. More specifically, nuclear reactions induced by deuterons (i.e., d-NRA) serve as an ideal analytical tool for determining the depth profile concentrations of nearly all the main light isotopes in materials' near surface layers. The (d,α) and (d,t) reactions are particularly advantageous for the study of ^{13}C, whereas the (d,p) reaction is ideal for the simultaneous determination of the depth profile concentrations of both ^{12}C and ^{13}C in a single measurement. However, precise and coherent experimental datasets of differential cross sections [e.g. 1-2] are necessary for the implementation of the d-NRA technique. By raising the deuteron beam energy range up to 2 MeV, and adding detection angles, the current work aims to advance the study of ^{13}C concentrations at greater depths.

Hence, in the present study, experimental differential cross sections of the $^{13}C(d,p_0)^{14}C$, $^{13}C(d,p_1)^{14}C$, $^{13}C(d,\alpha_0)^{11}B$, $^{13}C(d,\alpha_1)^{11}B$ and $^{13}C(d,t_0)^{12}C$ nuclear reactions are presented. The differential cross sections were defined using the relative measurement technique, in the deuteron beam energy range of $E_{d,lab}$ = 1000 – 2000 keV at six backscattering detection angles between 120^o and 170^o, with a 10^o step. For the measurements, the recently upgraded 5.5 MV HV TN-11 Tandem Accelerator of N.C.S.R. "Demokritos" in Athens, Greece, was used. Additionally, benchmarking measurements were carried out. Two targets were used for these measurements. The first was a glassy carbon (^{nat}C) target for charge/solid angle normalization, while the second was a ^{13}C pellet comprised of 95% ^{13}C and 5% cellulose ($^{nat}C_6H_{10}O_5$).

All the acquired results are compared to the existing datasets in the literature and any discrepancies are discussed and reviewed. The current coherent differential cross section datasets are believed to be able to pave the way for the theoretical investigation and forthcoming evaluation of all the deuteron-induced reactions that are suited for the study of ^{13}C depth profile concentrations in near surface layers of a variety of matrices, thus further reinforcing the capabilities of stable isotope carbon tracing in the near future.

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Differential Cross-Section Measurements of the $^{18}O(p, a_0)$ Reaction at 170° and 160°, in the Energy Range E_p=1-2MeV, for NRA Purposes

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Oxygen, the third most abundant element in the universe, offers multiple applications across various fields. Especially ^{18}O holds significant value for isotopic tracing purposes. Ion Beam Analysis (IBA) techniques, particularly Nuclear Reaction Analysis (NRA), are employed for the depth profiling of this isotope. While the historical study by Amsel in 1964 laid the foundation for NRA, inconsistencies in subsequent data have been identified. In order to address these discrepancies, the differential cross-section of $^{18}O(p,\alpha_0)^{15}N$ reaction was measured using the absolute measurement technique.

The target consists of a thin layer of Ta_2O_5 highly enriched in ^{18}O, deposited on a thick tantalum foil via anodization. The thickness of the target was provided by the manufacturer and independently verified experimentally using data from the $^{18}O(d,\alpha_0)$ reaction. The measurements were conducted at the HV TN-11 5.5 MV Tandem Accelerator of N.C.S.R. "Demokritos" in Athens, Greece. A proton beam within the energy range of 1-2 MeV was used, with a step size of 10-20 keV. Two detection angles, 170° and 160°, were measured, employing 500 μm thick Surface-Barrier-Back-Scattering (SSB) detectors.

To accurately determine the Q*Ω value, two methods were engaged. During the experiment, a gold-coated aluminum chopper was positioned at the entrance of the high-precision goniometric chamber. Additionally, SIMNRA simulations incorporating a pile-up calculation routine were performed to reproduce the proton elastic backscattering spectrum of the thick tantalum backing. The proton beam current was maintained at a relatively low level throughout the measurements, to minimize the pile-up effect.

The obtained results were compared with previously published data, allowing for a comprehensive analysis of both similarities and discrepancies. These coherent differential cross-section datasets are anticipated to facilitate the extension of the existing SigmaCalc evaluation of the $^{18}O(p,\alpha_0)$ reaction to higher energies in the near future.

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Dose distribution in boron neutron capture therapy for the treatment of brain cancer

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Boron Neutron Capture Therapy (BNCT) is a promising re-emerging therapeutic approach for brain tumors, such as glioblastoma multiforme, where other conventional treatments have limited efficacy. BNCT is based on neutron irradiation of tumors to selectively kill cancer cells that have accumulated boron compounds with high LET particles produced from the thermal neutron absorption reaction in B-10. Both nuclear reactors and accelerators are currently in use to obtain neutron beams with favorable characteristics. Depth-dependent absorbed dose distributions and absorbed dose to the critical brain structures in head phantoms during irradiation with neutron beams of different energy distributions and geometries were estimated using the MCNP6.1 code. Two sets of simulations were performed. The first set involves the study of the dose components as a function of depth in a homogeneous cylindrical head phantom consisting of water. The second one deals with the estimation of macroscopic dosimetric quantities to the critical structures in the voxelized Zubal anthropomorphic head/neck phantom [1]. Simulations were performed for different neutron beam energy spectra, beam areas, as well as boron concentrations in the tumor and the surrounding healthy tissues. The findings could contribute to the optimized irradiation of the target and spare of the patient's surrounding healthy tissues.

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Radiological characterization of ITER materials*

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Within the frame of the EUROfusion Work Package Preparation of ITER Operation (PrIO), materials used in the construction of ITER are irradiated at the Joint European Torus (JET), in UK, to study their properties under neutron irradiation in a real fusion environment. A set of ITER materials were irradiated at JET during the 2021 tritium-tritium (T-T) and deuterium-tritium (D-T) plasma experimental campaigns, with neutron flux levels and energy spectrum comparable to the one expected at ITER. After the completion of the irradiation, the samples were distributed to four labs (UKAEA, ENEA, IFJ, NCSRD) for gamma-spectroscopic measurements.

In this work, the gamma-spectroscopic analysis performed at NCSRD is presented. The activated samples were measured using a high purity germanium detector to quantify the induced radionu- clides activity. Correction factors were applied to account for the effects of true-coincidence summing and self-attenuation of photons within the sample material. The correction factor for photon self- attenuation was calculated using the MCNP code, while the TrueCoinc program was utilized to pro- duce true coincidence correction factors for all isotopes and energies of interest. The specific activities calculated for each sample were decay-corrected to a reference date, corresponding to the end of the irradiation.

The results will be compared against experimental values obtained by the other participating labs and, also, against theoretical calculations to validate codes and data used in ITER nuclear analysis. This work provides experimental data on the activation properties of materials used in ITER, which is an important aspect for the radiation protection of personnel and the safe handling of activated reactor components during maintenance activities, as well as for the decommissioning planning of ITER components and their safe disposal as waste or material recycling.

* This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Gamma-spectroscopic analysis of NORM samples

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In the present work, two samples of Naturally Occurring Radioactive Materials (NORM) were studied using gamma-spectroscopy. In particular, a phosphate ore and a phosphogypsum sample, from a phosphate fertilizer Greek industry, were measured at the NCSR "Demokritos" INRASTES gamma spectrometry laboratory in order to determine their radioactivity levels. The samples were provided by the Greek Atomic Energy Commission (EEAE) within the frame of an Intercomparison exercise, jointly organized by the International Atomic Energy Agency and the EEAE.

Prior to the gamma measurements, the humidity and density of each material were determined. Customized containers of standard geometry were filled with phosphate ore and phosphogypsum and then were sealed with epoxy resin in order to prevent gaseous isotopes, such as Rn-222, from escaping. After a period of 90 days, that allowed the isotopes of the Uranium series to reach equilibrium, the samples were measured using a High-Purity Germanium detector. The Full Energy Peak Efficiency calibration of the detector was performed experimentally, using reference volume sources of the same geometry and density as those of the samples. To account for the true coincidence summing effect and the self-attenuation of gamma-rays within the samples volume, appropriate correction factors were calculated using the TrueCoinc software and the MCNP code, respectively. The gamma spectrometry results were expressed in terms of specific activity for each isotope detected.

In both samples Ac-228, Bi-214, U-235, Pb-214, Pb-212, Th-234, Tl-208 and K-40 were detected, with activity levels varying per isotope. The results of the present study provide important information on the activity levels of NORM that are of particular interest for the phosphate fertilizer industry but also for industries involving NORM in general, for Occupational Radiological Exposure assessments of the workers, as well as for the protection of the environment. The results of the current study will be compared against experimental values acquired by other labs in Greece and abroad, contributing to the harmonization of NORM characterization, which is crucial for the safety of workplaces and industrial sectors involving such materials.

Quantifying athermal recombination corrected radiation damage in ion irradiated Fe and W utilizing the SRIM code.

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In radiation damage studies, the unit of displacements-per-atom (dpa) is typically used as a measure of radiation exposure, mainly due to its conceptual simplicity and the ability to compare results obtained under different irradiation conditions. Currently, dpa calculations are performed according to the Norgett-Robinson-Torres (NRT) model [1]. Regarding ion irradiation, this model is embedded in the most widespread software tool for ion transport calculations: SRIM. SRIM offers a friendly user interface and an extensive database of stopping powers of ions in materials. In the "Full-Cascade" (F-C) simulation mode, SRIM employs these detailed stopping powers also for secondary ion recoils. Thus, this mode gives the most accurate estimation of energy deposition in the target. Alternatively, the much faster "Quick Calculation" (Q-C) mode can be used, which employs Lindhard's approximation for the energy partition of secondary recoils. Many works were carried out in order to evaluate differences in (NRT-dpa) results obtained by these modes [2], [3].

A correction to the standard NRT-dpa exposure calculation has recently been proposed, which takes into account intra-cascade recombination: the athermal recombination corrected – dpa (arc-dpa) [4]. This correction is not yet implemented in any widely used software, including SRIM. However, different methods have been proposed for obtaining arc-dpa damage parameters by post-processing SRIM output [4], [5].

In the current contribution we study the calculation by SRIM of arc-dpa damage parameters in two elemental metals with great interest for fusion materials research: Fe and W. The SRIM calculations are performed in both the F-C and Q-C simulation modes. We discuss the differences in the damage parameters obtained with the two modes and compare our results to previous studies [3,4,5].

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Monte-Carlo calculations of evaporation and fission in excited spallation reaction fragments

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The subject of the present study is the transcription of the Java program MCEF [1] into FORTRAN. The program is suitable for fast Monte-Carlo calculations of the evaporation process including fission of highly excited fragments produced in spallation nuclear reactions. We studied the Java algorithm, analyzed the physics that govern the de-excitation process, converted the physics into FORTRAN functions, checked that the program's fundamental functions work properly and compared the program's results to experimental data [2,3]. The evaporation process translates well into the code, which has the advantage of being easily understood by the user, runs quickly, and is compatible with available related programs. Comparisons with the experimental data indicate the need for possible improvements and extensions of the present code.

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Talys calculations for α capture reactions on Cu isotopes

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Astrophysical models are unable to properly predict the abundances of the p-nuclei that have been detected in our solar system. The reason for this, is that a complex reaction network must be considered for the corresponding abundance calculations. In these calculations, beside the stellar conditions, the relevant reaction rates, i.e. the cross-sections, must be entered as input. Measuring each cross-section of the network is nearly impossible, not only due to the huge number of reactions and isotopes involved, but also because isotopes far from the valley of stability are included in the network. As a result, the Hauser-Feshbach (HF) theory's cross-section predictions play a significant role in abundance calculations. To comprehend how the theoretically predicted abundancies differ from the observed, it is crucial to assess the nuclear parameters used in HF calculations[1].

Following the experimental measurement of the cross-sections of the reaction ^{63}Cu(α,γ)^{67}Ga at astrophysical relevant energies, theoretical calculations were performed using the latest version (1.96) of the nuclear reaction code TALYS[2]. More specifically, all available models for the α-particle Optical Model Potential (OMP), the Nuclear Level Densities (NLD) and the γ-ray Strength Functions (γSF) were used in the calculations, as well as all the combinations of the aforementioned parameters, resulting in a large number of theoretical calculations. The scope of this study was to determine which of the HF calculations better describe the experimental data. The same procedure was followed for the ^{65}Cu(α,γ)^{69}Ga reaction, in order to more thoroughly examine how the various models affect the cross-section calculations in this mass region. This work is still in progress. Preliminary results will be resented within this contribution.

* This work is supported by project "Dioni: Computing Infrastructure for Big-Data Processing and Analysis" (MIS No. 5047222) co-funded by European Union (ERDF) and Greece through Operational Program "Competitiveness, Entrepreneurship and Innovation", NSRF 2014-2020.

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Radio-dating method of ^{210}Pb in a marine sediment core from the deep basin Northern of Skyros Isl., Aegean Sea

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In this work, the level of natural and artificial radioactivity in a marine sediment core obtained from the Northern basin of Skyros (Sporades region - Aegean Sea, Greece) was measured by a high-purity germanium detector. More specifically, the massive activity concentration was determined for the radionuclides of ^{226}Ra, ^{214}Pb, ^{214}Bi and ^{210}Pb, ^{208}Tl and ^{228}Ac, the natural potassium radioisotope ^{40}K and the anthropogenic cesium radionuclide ^{137}Cs. The vertical distribution was obtained for each of them in the core and subsequently, based on the radio-dating method of ^{210}Pb, the time reconstruction of their activity was realized. The sediment accumulation rate was calculated at (0.17 ± 0.02) cm y^{-1} which in the specific core is equivalent to sediment deposition of 1cm per (6 ± 1) years. The vertical distribution of ^{137}Cs was also used to validate the accumulation rate. According to the time reconstruction, a significant increase of both ^{226}Ra and ^{208}Tl was revealed in the period 1950-1960. The results highlight that the radio dating method of ^{210}Pb, even though is widely used in coastal marine areas, can be successfully applied in deep-sea regions where the accumulation of sediment is high enough (mm per year) due to sediment gravity flow.

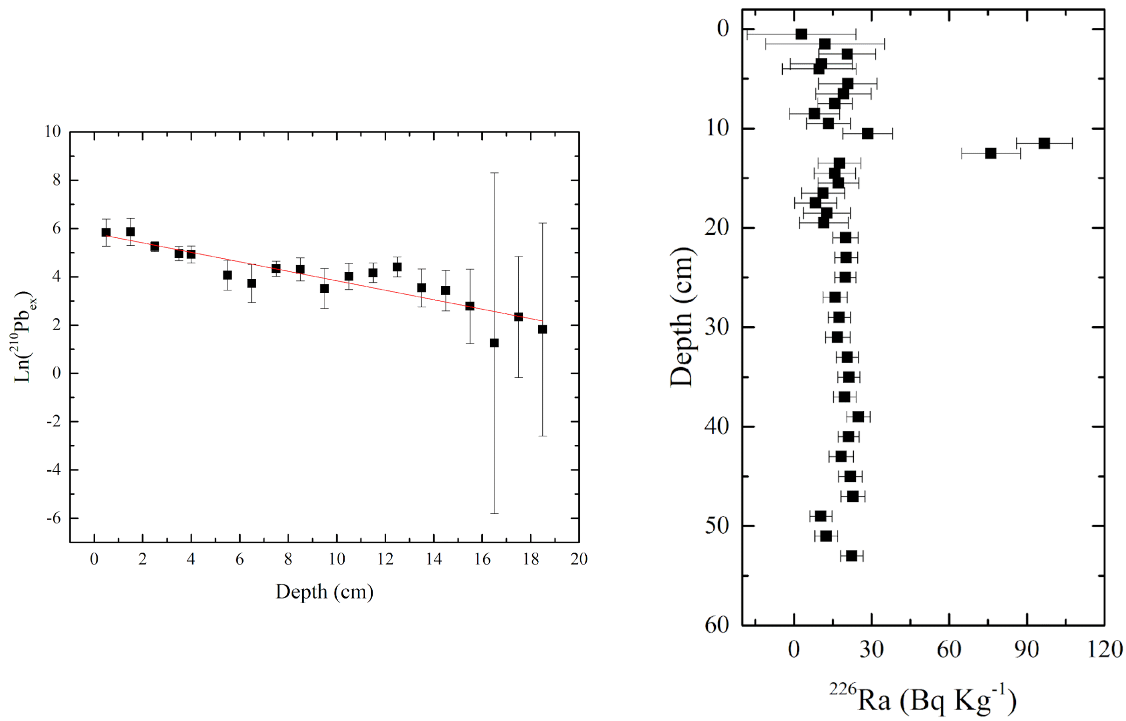

Figure: a) Activity concentration distribution of ^{210}Pb excess as a function of core depth in logarithmic scale, b) Activity concentration distribution of ^{226}Ra

EDXRF anlysis of metallic powders used in 3D printing of dental prosthetics

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The non-destructive analytical technique of EDXRF (Energy Dispersive X-Ray Fluorescence) is used in the Nuclear Engineering Laboratory of Mechanical Engineering School at the National Technical University of Athens (NED-NTUA) for the qualitative and quantitative analysis of a variety of samples.

Metallic powders, used in 3D printing processes for dental applications, especially for the Selective Laser Sintering (SLS) process for the additive manufacturing of Dental prosthetics, were analysed in the XRF facility of the Nuclear Technology Laboratory for this work. Metallic powders from three different providers, in Greek dental market, were sampled. The metallic powders wer mixed with binder and pressed into a pellet form using a hydraulic press.

The XRF facility consists of an X-ray chamber with Mo target and a SiLi detector. The appropriate analysis scenario is operating the X-Ray chamber at 35kV and using a Mo-filter in front of the exit of the X-Ray beam. The spectra collected were analysed by bAXIL, a spectrum analysis software, based on the standard based fundamental parameters method. For the quantitative analysis, pressed pellet standards were prepared using high purity metal oxides and salts.

The XRF analysis concluded that the metallic powders for dental prosthetics were composed mainly of Co (65%), Cr (25%), W(5%), Ni(3%) and in very low concentrations of Mn (0.3%) and Au (0.2%). The corresponding uncertainty and Lower Limit of Detection were also estimated for each element.

An operational radiation safety intervention: Minimizing dose in lab spaces due to photon sources in adjacent storage room

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The Nuclear Engineering Laboratory of NTUA (NEL-NTUA) operates an industrial radiography installation since about 2010. The installation incorporates a 200 kVp industrial radiography -x ray unit placed in a basement -x ray vault space. At the licensing of the installation by the Greek Regulator and during the characterization phase of the control zones, the supervised zones and the general public zones, it was made obvious that there existed increased and potentially harmful background within the control zones, which at a very limited number of points, easy to be avoided, reached 1.5 μSvh^{-1}. It was consequently established that this background was due to -γ emitting sources stored in adjacent to the -x ray vault and the control zones storage room. The situation was further investigated by dose data measurements for the construction of the 2D dose maps at various elevations within the control zone spaces. Dose data were collected using a portable radiation monitor [1]. The data collection grid was set to about 0.5×0.7 m for approximately the following elevations: 0.00 m (floor), 1.00 m, 1.70 m and 2.20 m. Maps were drawn by suitable software using the kriging method [2]. Results demonstrated that photons contributing to dose emerged at a height of about 1.00 m, from the NW wall of the -x ray vault space, behind which the source storage room of the Laboratory is located. Further visiting the storage room, it was established that photon sources were actually placed behind this wall in drums without any particular shielding. Given the dose data mapping, it was decided to move the sources away from this wall to the SW wall of the storage room and shield them circumferentially with standard lead bricks. The positive result of this intervention was verified by remapping the dose rate in the control zones for the worst case scenario of the 1.0 m elevation. It was thus established that doses were significantly minimized and that they were not considered as potentially hazardous any more.

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Study of the ^{233}U(n,f) reaction cross section using Micromegas detectors

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A safe and secure, sustainable, and reasonably priced energy production technology is highly desirable to meet the ever increasing present and future energy needs of humanity. The utilization of nuclear energy through new generation nuclear reactors, such as Generation IV Reactors and Acceleration Driven Systems - ADS, which are significantly more fuel-efficient, comply with strict safety and proliferation resistance standards, and seem to resolve the key issue of long-lived nuclear waste, appears to be a promising solution to this problem.

Due to thorium's higher abundance (10.5 ppm compared to 3 ppm of uranium) and superior nuclear characteristics, the Thorium cycle has a plethora of potential advantages over the Uranium one, which is used in the majority of currently functioning commercial reactors. The fertile isotope ^{232}Th transmutes into the fissile isotope ^{233}U upon neutron absorption, which is superior to the currently used isotopes ^{235}U and ^{239}Pu, due to its larger neutron production per thermal neutron absorbed in the fuel (η factor). As far as sustainability is concerned, thorium, as a lighter nucleus, produces less transuranic isotopes, thus lightening the long-term burden of disposing nuclear waste. The utilization of the thorium cycle in future generation reactors could potentially provide a long-term solution to humanity's energy demands due to its abundance and capacity to generate fissile material. [1]

The aforementioned factors triggered the present work. The neutron-induced fission cross section of ^{233}U was studied for nine incident neutron energies in the energy range $E_n = 2 - 4.5\ MeV$, since there are serious inconsistencies between evaluated databases and experimental datasets in this energy range. The experiment was carried out at the 5.5 MV Tandem Van de Graaff accelerator of NCSR "Demokritos". The neutron beam was produced via the ^{3}H(p,n)^{3}He reaction, using a solid TiT target. Seven actinide targets were implemented, each coupled with a Micromegas detector, into an aluminum chamber containing an Ar:CO_2 (80:20) gas mixture in constant flow, in order to accurately detect the emitted fission fragments. The total yield of fission fragments was used to determine the neutron-induced fission cross section of ^{233}U in relation to the corresponding ones of reference targets. All target masses were determined by alpha spectroscopy offline, using a Silicon Surface Barrier (SSB) detector in D-Chamber under vacuum condition.

The careful examination of low-energy parasitic neutrons, produced via proton-induced reactions in the beamline and on the target, was deemed crucial. Monte Carlo simulations were performed, using a combination of the NeuSDesc and MCNP5 codes, to simulate the flux of the produced neutrons on each of the seven actinide targets.

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A study of the nuclear structure of even-even Te isotopes using the IBM-1*

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The even-even Tellurium isotopes are part of a region beyond the closed proton shell at Z=50, which are considered to exhibit vibrational-like properties. The motivation of this work is to study, calculate and estimate the energy levels, transition quadrupole moments and the reduced transition probabilities B(E2) of the even-even $^{106-140}$Te isotopes within the IBM framework. In addition, the deformation parameters 2 and γ have been calculated providing a useful visualization of the nuclear shapes.

For the calculations with the IBM, the program IBAR has been used to obtain the experimental data for each isotope. Furthermore, with a simple set of polar coordinates the two Hamiltonian parameters can be plotted within the IBM symmetry triangle and the trajectories of different isotopic chains can be compared. The results have been compared to available adopted data and used as predicted estimates for the currently unknown case.

Cross section biasing in $^{3}H(d,n)^{4}He$ reaction using the GEANT4 toolkit

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In this study, a simulation code is developed using the GEANT4[1] toolkit to investigate and quantify neutron production from deuteron-induced reactions. The main purpose is to properly study the neutron generation using the technique of cross section biasing to reduce computing time. However, the implementation of a biasing technique can significantly impact the physical processes simulated. To evaluate the effectiveness of the biasing technique, validation simulations using different materials, geometries and biasing factors were performed and the results were compared to the unbiased cases.

At the Tandem accelerator laboratory of the N.C.S.R. "Demokritos"[2], the $^{3}H(d,n)^{4}He$ reaction is used for neutron beam production. The tritium flange contains molybdenum, copper and titanium elements. During the deuteron beam interaction with these elements, there is a probability of secondary neutron generation that can result into undesired parasitic neutron production and contamination of the main neutron beam.

Various target materials are purposefully exposed to a neutron beam in order to conduct cross-section measurement experiments. The simulation code aims to understand neutron flux distribution and transport through the targets. The corresponding results obtained using GEANT4, through the application of biasing techniques, were compared to those resulting from the combined use of MCNP [3] and NeuSDesc[4] codes. The final results will contribute to a deeper understanding of the neutron production using the $^{3}H(d,n)^{4}He$ reaction and the resulting flux shape, and aid in the accurate study of neutron-induced reactions with this flux.

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Radioactivity studies in soils from Northwestern Greece

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Natural radioactivity is examined in soil samples collected from North Western Epirus, specifically in Pogoni and Zagori areas. The focus was to determine experimentally the specific activity for six naturally occurring isotopes (^{40}K, ^{208}Tl, ^{212}Pb, ^{214}Pb, ^{214}Bi, ^{228}Ac) and one artificial (^{137}Cs) in the samples collected from a generally unexplored area of Greece.

The measurements were carried out with the use of two High-Purity Germanium (HPGe) detectors [1], calibrated with two different bulk geometry samples. For the analysis of the spectra, SPECTRW [2] was used. Based on the measurements of specific activities, the absorbed dosage and index of external hazard, H_{ex} have been estimated through models of UNSCEAR [3], contributing to the level of environmental sustainability of the area.

In conclusion, in the area of sampling, radioactivity levels have been found to be similar with other areas of Greece. Indicatively, the maximum value of ^{40}K is determined to be 271(8) Bq/kg and the maximum value of absorbed dosage rate is calculated to be 29(1) nGy/h.

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Installation of the new TOF – ERDA setup at N.C.S.R. “Demokritos”

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Time of Flight - Elastic Recoil Detection Analysis (TOF –ERDA) technique is one of the most suitable Ion Beam Analysis (IBA) techniques for surface analysis and thin foil characterization. A new Time of Flight spectrometer has been installed at the Tandem Laboratory of N.C.S.R. “Demokritos”. High accuracy of mass separation and depth resolution regarding light elements is achieved by the determination of time-of-flight between two timing detectors and the total amount of energy deposited on the silicon surface barrier detector (SSB).

The spectrometer is mounted on the 30^{o} port of the goniometric chamber at the R2 beamline. The two Microchannel Plate (MCP) detectors, using carbon foils for the detection of the charged particles, are mounted in the telescope with a distance of 540mm between them. The SSB detector is placed 5mm away from the second MCP detector. The detection angle of the telescope is 30^{o} with respect to the beam axis. Appropriate collimators were placed in front of the timing detectors as well as at the entrance of the telescope to minimize the detection solid angle and avoid multiple scattering effects.

Due to the low number of emitted secondary electrons triggered by the passage of light elements through the carbon foils, the spectrometer’s efficiency varies with respect to the ion type and energy. The determination of the setup efficiency for light elements was conducted by the detection of scattered ions on Au thick target. The newly installed TOF-ERDA system as well as preliminary results for the efficiency of the system will be presented.

Spectroscopic limitations of hand-held γ-spectrometers*

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The results of an intercomparison of three hand-held γ-spectrometers are presented in this work. More specifically, two identical Thermo RiidEye M-G3 Ø 3" x 3" detectors and one Target Identifinder Ø 1.4" x 2" NaI(Tl) detector were tested for their responses in cases of shielded or unshielded sources. This study aimed to investigate the spectroscopic limitations and capabilities of hand-held γ-spectrometers and to calculate the detection thresholds for hidden sources.

Different radioactive sources were used: (a) Cs-137 with an activity of 6.17 MBq, (b) Eu-152 with an activity of 1.28 MBq, (c) Cs-137 with an activity of 25.9 kBq, and (d) Na-22 with an activity of 3.9 kBq. Experiments were conducted to eliminate the influence of various geometries, which were either identical or symmetrical. Measurements with shielded and unshielded sources were taken at different distances ranging from 0 to 4 meters from the tested RIIDs.

A very good correlation was observed between the three hand-held γ-spectrometers, regarding their response in external dose. Although the two NaI(Tl) 3″ × 3″ detectors were identical, a difference of 1.2% was observed between them. There was also a 0.4% difference in the measurements of dose rate between the first 3″ × 3″ detector and the 1.4″ × 2″ and 1.8% difference between the second 3″ × 3″ detector and the 1.4″ × 2″.

The estimated unscattered dose rate from the Cs-137 source, as determined by Monte Carlo simulations, varied with the distance from the source, It was found to be 10% to 40% lower than the measured dose rate. The detectors were unable to identify the radionuclides Cs-137 or Eu-152 under the following conditions: a) when the shielding distance resulted in a dose rate less than twice the background, or b) when the count rate was high.

In the case of a high-count rate, there was a spectrum shift that could lead to incorrect identification of radionuclides when using automatic identification without human intervention.

* This work has been implemented under the support of IAEA CRP project J02014 “Advancing Maintenance, Repair and Calibration of Radiation Detection Equipment”

Studying muonic atoms with advanced numerical solutions of the Dirac-Breit-Darwin equation*

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It is well known that, the Dirac equation constitutes an optimal approach for the relativistic description of muonic atoms [1, 2] as well as purely leptonic atoms like the Muonium (μ^+, e^-) 2-body system [3]. However, several energy corrections like the ones included in the Breit-Darwin equation describing additional interactions between the μ^--nucleus or μ^--electron systems, must be included in the calculations [4, 5].

One of our main goals in this work is to provide accurate wave functions for the above mentioned systems with numerical solutions of the Dirac equation involving Breit-Darwin terms in order to provide theoretical predictions of high-accuracy for the following:

(i) The contribution of the small (bottom) component, g(r), of the μ^- in muonic atoms. Previous predictions of the ordinary muon-capture rates have either ignored the contribution of g(r) [1] or utilized the non-relativistic Schrödinger equation which by definition considers g(r)=0 [2].

(ii) The bound spectrum of the Muonium purely leptonic atom that provides excellent tests of the quantum electrodynamics (QED theory) as well as of several beyond the Standard Model (BSM) theories. We mention that, in general the structureless purely leptonic atoms like the Muonium (Mu), Positronium (Ps), etc., are ideal systems for testing the QED and BSM theories. Recently, Mu and Ps are thoroughly being investigated towards the above purpose.

* This work is financially supported by: "The Association for Advancement of Research on Open Problems in Nuclear Physics & Particle Physics (OPRA Association)", Tel Aviv, Israel.

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Derivation of advanced Python code for solving the Dirac-Coulomb-Breit equation in muonic atoms *

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In this work, initially the Dirac-Coulomb equation for exotic muonic atoms is formulated in the relative coordinate r of the muon-nucleus system by separating out the center of mass motion [1,2]. Then, an advanced algorithm (in Python language) is derived on the basis of the neural networks techniques for solving numerically this equation and obtain the large (upper) f(r) as well as the small (bottom) g(r) components of the muon orbiting around a nucleus.

For the required optimization process, an error function of a concrete muonic system is defined and the BFGS or trust-constr methods (as provided from the SciPy submodule optimize) are being utilized [3]. Finally, in order to asses the confidential level of the designed algorithm, the numerical solutions are compared with the corresponding analytic wave functions of the Dirac-Coulomb equation [4].

One of our main goals of this work is to test previous muon capture predictions obtained by solving the Schrödinger equation for several muon-nucleus systems [4,5] and, then, to perform systematic studies on exotic purely leptonic atoms that are promising probes to test the quantum electrodynamics and beyond the standard model theories. Our numerical method provides fast and accurate numerical solutions of the Dirac-Coulomb equation a fact that encourages us to apply the same scheme to solve the corresponding Dirac-Coulomb-Breit equation which includes higher order relativistic corrections for the description of the aforementioned exotic atomic systems.

* This work is financially supported by: "The Association for Advancement of Research on Open Problems in Nuclear Physics & Particle Physics (OPRA Association)", Tel Aviv, Israel.

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