1. **Shape Coexistence versus Shape Phase Transitions in nuclei studied via two-nucleon transfer reactions - THEO**

Supervisor:

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Abstract:

Even though nuclei are made of A separate nucleons interacting between each other, some of them show in their characteristics clear patterns of an underlying collectivity. An example is the fact that nuclei present different shapes: they can be spherical, prolate, oblate... A nucleus will be prolate or spherical depending on the detailed movement of the A nucleons: a doubly closed shell nucleus is always spherical and a large part of open shell nuclei are prolate. If we go along different isotopes from one shell closure to the next one, we will face a shape phase transition: we will start with a spherical nucleus, then we will arrive to an isotope which has a prolate shape and, finally, as we reached the following shell closure, we will end at a spherical nucleus again.

A more controversial point is whether we can have shape coexistence and how to distinguish it from a shape phase transition. In shape coexistence we can have a nucleus whose ground state is, for example, prolate whereas some of its excited states are oblate or spherical. Even more importantly, If these states are close, they can be mixed. A possible tool to distinguish these different cases could be two-neutron transfer reactions. This reaction has been shown to be sensitive to the different shape phase transitions [R. Fossion et al., Phys. Rev. C76, 014316 (2007)] since the probability of transferring two particles decreases quite fast when the initial and final nuclei have different shapes.

Along the present project, the student is expected to learn the Interacting Bosson Model and how, within this model, we can study shape transitions and shape coexistence. The student will later calculate intensities for the different two-neutron transfer reactions which will later be calculated within the Distorted Waves Born Approximation.

2. **Measurement of long-lived radionuclides in atmospheric samples by Accelerator Mass Spectrometry (AMS) - APP**

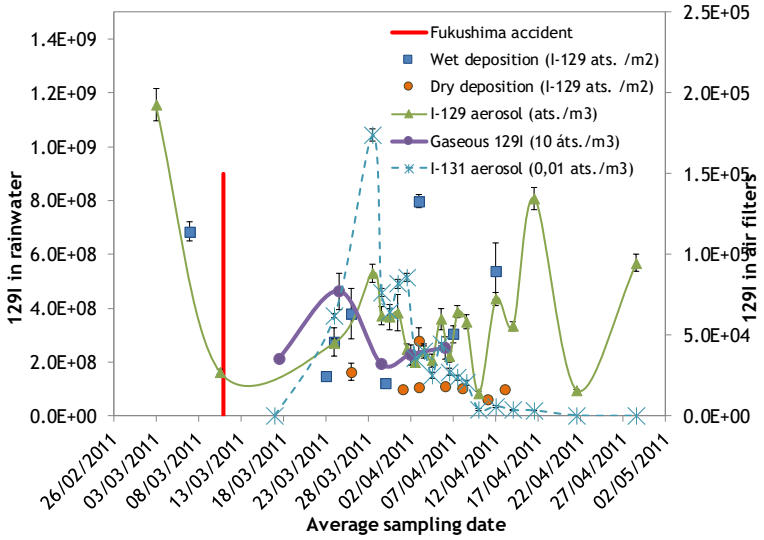
Supervisors: Manuel García León (manugar@us.es) and José María López Gutiérrez (lguti@us.es).

The origin of radionuclides in the atmosphere can be both natural and artificial. In any case, especially if these radionuclides have a long half-life, it can be very interesting to analyse the evolution of their concentrations in the air, as the are excellent tracers of environmental processes. This can give information on their origin, transport and exchange of matter between different environmental compartments.

The use of radiometric techniques to detect long-lived radionuclides is often very inefficient and therefore does not allow evaluating their presence in the air with enough sensitivity. This happens commonly in environmental samples. The use of Accelerator Mass Spectrometry (AMS) is an alternative. This technique is based on the use of accelerators and presents much higher sensitivity.

At the Centro Nacional de Aceleradores (CNA) in Seville, we propose to explore the sensitivity limits of the Accelerator Mass Spectrometry technique in the measurement of atmospheric samples, under the

supervision of the Applied Nuclear Physics group of the University of Sevilla. This group has more than 20 years of experience in this technique and an excellent reputation at an international level.



3. Development of a versatile software for data analysis in Accelerator Mass Spectrometry (AMS) at the Centro Nacional de Aceleradores (CNA) - APP

Supervisors: Francisco Javier Santos (fj.santos@csic.es) and José María López Gutiérrez (lguti@us.es)

Accelerator Mass Spectrometry (AMS) is an accelerator technique that is able to detect long-lived radionuclides in very little concentrations in different matrices. The quality control of the measurement is carried out, among other points, by the use of standard and blank samples that give information on the transmission, background, contamination, instabilities, etc.

In order to obtain the final result of the isotopic ratio in a concrete sample, a complex data analysis in necessary. This includes the extraction of the data from the individual measurement results and the correction to the real value for the isotopic ratio in the sample.

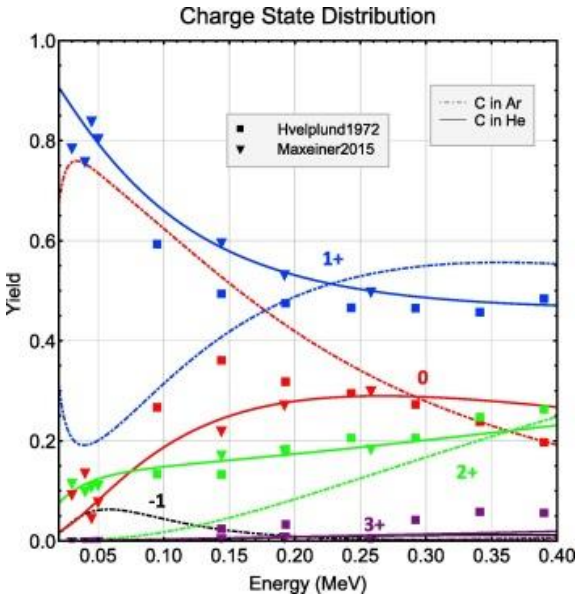
In this work we propose to develop software for a fast analysis of the data. In order to do this, not only programming skills are needed but also a good knowledge of the Physics involved in AMS. The candidate will be trained at CNA in the technique and will participate on the measurements and in the ongoing projects of the Applied Nuclear Physics group of the University of Sevilla.

4. Measurement of 14C with He stripping on the 1 MV Accelerator Mass Spectrometry system (AMS) at the Centro Nacional de Aceleradores (CAN) - APP

Supervisors: Francisco Javier Santos (fj.santos@csic.es), Elena Chamizo (echamizo@us.es) and Manuel García León (manugar@us.es).

Accelerator Mass Spectrometry (AMS) is an ultrasensitive technique able to detect isotopic ratios as low as 10-15 in which stripping process plays a key role. The stripping process occurs in the terminal of an electrostatic tandem accelerator, where the atomic species extracted as negative anions (i.e. X-1), lose electrons when interacting with a gas medium, resulting in a distribution of ions with positive charge states Xn+. The energy of the beam (i.e. the accelerator terminal voltage) and the stripper gas pressure, are two fundamental parameters in order to make the best use of the technique. Recently, the stripper gas system attached to the 1MV AMS system at CNA, SARA, has been changed from Ar to He [1]. The aim of this work is to study the performance of the system with the new stripping conditions for radiocarbon (i.e. 14C) measurements. It will include two stages: i) the study of the stripping yields of C1+, C2+ and

C3+ on He gas at 1 MeV and below; and ii) the assessment of the most appropriate measurement conditions for 14C for dating purposes on a routine basis, both in terms of efficiency and background figures. Additional information on the stripping process of C on He gas in the 400-1000 kV range might be obtained, extending the information available in the literature so far [2] (see figure below). The 1 MV AMS system at the CNA is the only one of its kind in operation in Spain, and has a consolidated trajectory as far as the measurement of rare long-lived radionuclides is concerned.



Charge state distribution of 12C with He and Ar stripping gases below 400 keV. Figure extracted from [2].

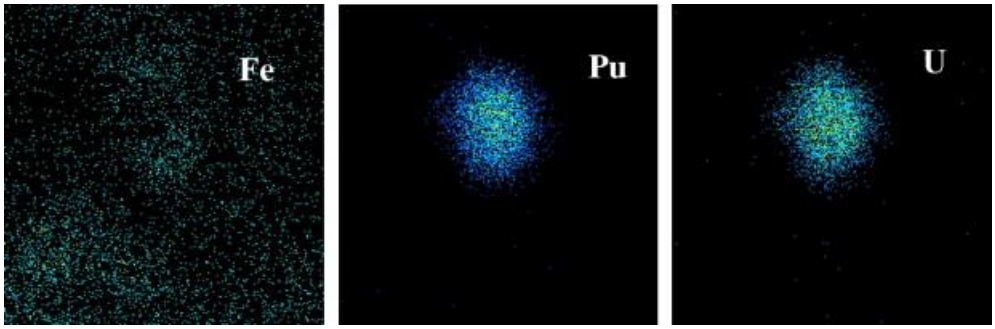
5. Actinides studies on hot particles by Accelerator Mass Spectrometry (AMS) at the Centro Nacional de Aceleradores (CNA) - APP

Supervisors: Mª Carmen Jiménez-Ramos (mcyjr@us.es) and Elena Chamizo (echamizo@us.es).

Following nuclear events such as nuclear weapons tests and nuclear accidents, particles of different sizes containing actinides in high concentrations are released into the environment. 235U (T1/2=7.04x108 y) and 239Pu (T1/2=24110 y) are the fissible radionuclides that have been used as a source of nuclear energy in nuclear weapons and reactors, therefore U and Pu isotopes and the major constituents of those so-called hot-particles (HP) (see figure below). To date, much information on HP composition has been published on a series of radionuclides that can be determined by conventional radiometric (e.g. alpha or gamma spectrometry) and/or mass spectrometry techniques (e.g. ICPMS). This is the case of 241Am (T1/2=432.2 y) (i.e. decay product of 241Pu (T1/2=14 y)), 239Pu, 240Pu (T1/2=6524 y) (i.e. produced by neutron activation of 239Pu) and 234,235U (ie. naturally occurring but with a different isotopic composition in nuclear devices). However, there is almost any information on 237Np (T1/2= 2.14x106 y) and 236U (T1/2=2.34x107 y). 237Np is produced from neutron reactions on 238U and 235U and is the decay product of 241Am. 236U is mostly produced by neutron activation of 235U. Relevant information on the source of the hot particles and on their history of irradiation can be obtained from the study of their isotopic abundance in HP, in combination with Pu and U isotopic ratios.

At the CNA, HP samples from different scenarios are available: i) from Trinity nuclear test site in New Mexico, where the first US nuclear detonation was carried out in 1945; ii) from Semipalatinks nuclear test site, the main proving grounds by the former Soviet Union in the period 1949-1989; and iii) from Thule (Greenland) and Palomares (Spain), where the fuel of thermonuclear devices was spread accidentally in 1966 and 1968, respectively. Actinides measurements (236U, 237Np, 239,240Pu and

241Pu(241Am)) will be performed on the 1 MV Accelerator Mass Spectrometry (AMS) system at the Centro Nacional de Aceleradores (CNA, Seville, Spain). This device is the only AMS system in operation in Spain, and is part of a short list of AMS devices worldwide that have demonstrated their potential to measure actinides on a routine basis.



Elemental maps of Fe, Pu and U for a hot particle. The scan extent is 75 × 75 μm2. Figure extracted from [3].

6. Synthetic equilibria for the new Seville Spherical Tokamak - APP

Supervisor: E. Viezzer y M. Garcia Muñoz (eviezzer@us.es)

A new spherical tokamak for the University of Seville is currently being designed. Spherical tokamaks are like standard tokamaks with a slightly different shape that allows to make a more efficient use of the confining magnetic fields. Within this work several equilibria taking into account the main design parameters will be studied using the FIESTA code. FIESTA is an objectoriented code that solves the equilibrium configuration of a plasma based on the Grad-Shafranov equation using the current of the coils of the tokamak as input, and computes the temporal evolution of the plasma current. A parameter scan including triangularity and elongation of the plasma will be carried out and optimized in terms of resulting plasma pressure.

7. Implementation of fluid equations in PETGEM (in collaboration with Polytechnic University of Catalonia and Barcelona Supercomputing Center) - APP

Supervisor: E. Viezzer y M. Garcia Muñoz (eviezzer@us.es)

PETGEM is a parallel python code for 3D Controlled-Source Electromagnetic Method (3D CSEM) in geophysics. As main features of this code are support for unstructured adapted meshes, high-order polynomial approximations (edge-elements or curl-conforming elements), simple and clear Python syntax, and support for high-performance computing (HPC) architectures. This code is designed to cope with the main challenges encountered within the numerical solution of the Maxwell's equations in its curl-curl form with high flexibility and accuracy. PETGEM is opensource under the GPLv3 license, which clearly facilitates its efficient deployment on diverse computing platforms, the solution of test cases that are realistic regarding both spatial scales and geological properties, and its flexibility to adapt it to other scientific fields.

The goal of this project is to extend PETGEM to include magnetohydrodynamic (MHD) effects, i.e. to combine the already implemented Maxwell equations with the fluid equations in the code. More concretely, the following tasks will be required:

- Creation of adapted meshes for MHD modeling
- Time-integration implementation for Maxwell's equations in the context of MHD

• Design, execution, and analysis of test cases

8. Machine learning for the interpretation of the edge main ion charge exchange spectra at ASDEX Upgrade - APP

Supervisor: E. Viezzer y M. Garcia Muñoz (eviezzer@us.es)

Charge exchange recombination spectroscopy (CXRS) is a widely extended technique to evaluate ion temperature and rotation in tokamaks [1]. The technique is based on the observation of spectral lines, typically fully-ionized impurities which emit light after a charge exchange reaction with diagnostic neutrals. The Doppler shift, width and intensity of the line allow for the evaluation of rotation, temperature and density, respectively [2]. The main ion spectra is rarely analyzed because its interpretation is substantially more complex than for impurities due to the halo effect. The halo is a thermal neutral population which is born in multiple generations after the first direct charge exchange (DCX) reaction between the thermal plasma and the diagnostic neutral.

The interpretation of the main ion Dα spectra strongly relies on forward modelling of the halo neutrals and their contribution to the spectra. The FIDASIM code [3,4] is an excellent tool for our purpose. FIDASIM is a Monte Carlo code that calculates the neutral density of several deuterium populations and its associated photoemission, so it can model all contributions to the main ion spectra.

The interpretation of the core main ion spectra has been speeded up by using look up tables based on FIDASIM simulations [5]. At the plasma edge, due to the steep gradients, a more time iterative approach is adopted. In this work, we want to explore the possibility of applying neural networks (NN) for the reconstruction of the edge main ion spectra measured at the ASDEX Upgrade tokamak. The goals of the work are to construct a database with FIDASIM and use it to train a neural network. This NN should be able to, given an experimental spectrum, resolve the underlying deuterium properties which are responsible for the spectra

9. "Técnicas radioterápicas especiales y guiadas por imagen". - APP

Supervisor: Antonio Leal Plaza

Nuestra investigación contempla varias líneas de actuación que implican el modelado Monte Carlo y cálculo numérico del transporte de partículas en haces terapéuticos frente al cáncer. Se analizan haces en condiciones especiales, tanto físicas, por la naturaleza de las partículas o por estar sometidos a sistemas de colimación novedosos, así como biomédicas, combinándose con la presencia de agentes externos como nanopartículas. La metodología implica la evaluación de nuevo hardware y el desarrollo de software, vinculado a la generación del haz como a la detección y procesamiento para la imagen utilizada en el diagnóstico, planificación y guiado de tratamientos para la aplicación personalizada de la radioterapia.

10. Study of double-beta decays with the nuclear shell model - THEO

Supervisor: Javier Menéndez (University of Barcelona) menendez@fqa.ub.edu

Atomic nuclei are ideal laboratories to search for physics beyond the Standard Model. One the most exciting processes of this kind is neutrinoless double-beta (ββ) decay, where a nucleus decays by exchanging two neutrons for two protons emitting only two electrons and no neutrinos.

As a net effect, this process creates matter—two electrons. For this reason, it can be key to explain the prevalence of matter over antimatter in the universe. Several experiments worldwide are trying to detect neutrinoless ββ decay.

The decay rate of neutrinoless ββ decay is governed by a nuclear matrix element that needs to be calculated by nuclear theory [1]. In the absence of neutrinoless ββ decay data, the quality of theoretical calculations is evaluated confronting theoretical predictions of other observables related to double-beta decay where data is available.

This Masters Thesis work proposes to use the nuclear shell model [2], one of the most successful nuclear structure methods, to study nuclear matrix elements for neutrinoless ββ decay. In addition, related processes where experimental data is available will also be studied, such as ββ decay with the emission of neutrinos [3], or double Gamow-Teller transitions [4]. In particular, possible aspects to be investigated include

a) ββ decays with neutrino emission to excited states of the final nucleus

b) precision calculation of the energy spectrum of the electrons emitted in ββ decays

c) role of SU(4) symmetry in double Gamow-Teller transitions and ββ decay

d) neutrinoless ββ decay nuclear matrix element of 124Xe

Processes a), b) and c) are expected to be measured soon in some nuclei. The plan is to obtain theoretical predictions that will be tested against forthcoming experiments. Project d) involves the first shell model calculation of the neutrinoless ββ decay of 124Xe.

[1] J. Engel and J. Men´endez, Rep. Prog. Phys. 80, 046301 (2017).

[2] E. Caurier et al., Rev. Mod. Phys. 77, 427 (2005).

[3] E. Aprile et al., Nature 568, 534 (2019).

[4] N. Shimizu, J. Men´endez and K. Yako, Phys. Rev. Lett. 120, 142502 (2018).

11. Dynamically generated S=-1 resonances due to S-, P- and D-wave meson baryon interaction in chiral unitary model - THEO

Supervisor: V. Magas, A. Ramos (University of Barcelona)
Email: magas@fqa.ub.edu, ramos@fqa.ub.edu

In collaboration with A. Feijoo (Institute of Nuclear Physics, Rez-Prague) we have developed a model for the meson-baryon interaction in the strangeness S=-1 sector that includes S, P and D waves. The model employs a chiral SU(3) Lagrangian up to next-to-leading order (NLO) and implements unitarization in coupled channels. The master thesis study will depart from this model and will anaylse the results obtained from different parametrizations that fit different sets of data, focussing on the properties of baryon resonances that are generated dynamically within the model.

12. Study of baryon-baryon interactions (pL,LL and pX) with the femtoscopy method - THEO

Supervisor: A. Ramos (UB) / I. Vidaña (INFN-U Catania)
Email: ramos@fqa.ub.edu, isaac.vidana@ct.infn.it

The femtoscopy method allows one to obtain information about two-particle interactions from the measurement of correlated pairs in relativistic heavy ion experiments. The purpose of this master thesis is to obtain the correlators of several particle pairs (pL,LL and pX) employing wave-functions derived from several realistic interaction models, and compare them with the recent results obtained by the ALICE collaboration at LHC.

13. Properties of neutrons stars with exotic components studied within an analytic parametrization of the equation of state - THEO

Supervisor: A. Ramos (UB) / I. Vidaña (INFN-Catania)
Email: ramos@fqa.ub.edu, isaac.vidana@ct.infn.it

A simple analytic parametrization of the equation of state of nuclear matter with strangeness has been recently proposed. The parameterization reproduces with good accuracy the results of the microscopic calculations with a small number of parameters. The master thesis will apply this equation of state to obtain the properties of neutron stars (mass, radius, composition, tidal deformabilities, etc…), paying a special attention to the possible existence of exotic components (hyperons, D particles, antikaons…) in the internal core of the star. Sensitivity of the neutron star properties to the various parameters of the equation of state will be analysed.

Master thesis proposals in University Autonoma Madrid for 2019-2020

14. Nuclear structure studies with symmetry conserving configuration mixing methods - THEO

Supervisors

Luis M. Robledo (luis.robledo@uam.es)

Tomás R. Rodríguez (tomas.rodriguez@uam.es)

The most widely used phenomenological models to study the structure of atomic nuclei at low-excitation energies are the Interacting Shell Model (ISM)1 and the Self-Consistent Mean-Field (SCMF)2, and its Beyond-Mean-Field (BMF) extensions2. The ISM is currently the method that provides the best description of the spectra of the atomic nuclei due to the exact character of its solutions and the quality of the effective interactions used. However, its applicability is limited to certain regions of the nuclear chart.

The SCMF method is based on the variational principle to solve quantum many-body problems in an approximate manner and it can be applied to study on an equal footing stable nuclei and nuclei far away from the valley of stability. Furthermore, the SCMF methods give a very useful interpretation of the nucleus in terms of intrinsic shapes. However, BMF approximations are needed to describe more accurately nuclear masses, radii, spectra, transitions and decays. State-of-the-art BMF techniques are based on the so-called symmetry conserving configuration mixing (SCCM) methods with density-dependent interactions3.

This Master's Thesis proposal aims at the application of SCCM in the study of the structure of atomic nuclei. In particular, the role of collective coordinates as quadrupole and octupole deformations, pairing degrees of freedom, etc., will be analyzed in regions of current experimental interest (shape-coexistent nuclei, appeareance or degradation of magic numbers far away from stability, etc.).

Bibliography

[1] E. Caurier et al., Rev. Mod. Phys. 77, 427 (2005); T. Otsuka et al., Prog. Part. Nucl. Phys. 47, 319 (2001).

[2] M. Bender et al., Rev. Mod. Phys. 75, 121 (2003); J. L. Egido, Phys. Scr. 91, 073003 (2016); L. M. Robledo et al., J. Phys. G: Nucl. Part. Phys. 46, 013001 (2019).

[3] M. Bender, P.-H. Heenen, Phys. Rev. C 78, 024309 (2008); T.R. Rodríguez, J.L. Egido, Phys. Rev. C 81 064323 (2010); J.M. Yao et al., Phys. Rev. C 81, 044311 (2010).

Requirements

- Good knowledge on Many-Body Theories in Nuclear Physics.

- Computational skills (Linux OS).

- Programming skills (Fortran, C, Python, or similar).

15. Monte Carlo event generators for the simulation of neutrino-nucleus interaction - THEO

Supervisors: Raúl González–Jiménez (UCM), José Manuel Udías (UCM) raugonjim@gmail.com, jose@nuc2.fis.ucm.es

Why the Universe is made of matter instead of matter and antimatter in equal proportions? What is the nature and origin of dark matter?

The answers to these and other fundamental questions could be in the neutrino oscillation. This phenomenom, which shows that netrinos have mass, has opened the door to Physics beyond the Standard Model of Particle Physics and placed the study of these particles in one of the frontiers of the knowledge. DUNE (https://www.dunescience.org/) and Hyperkamiokande (http://www.hyperk.org/) are the two main projects that represent the community medium and long plans.

Monte Carlo (MC) neutrino event generators are a fundamental tool in these neutrino oscillation experiments. They are the necessary bridge between what is experimentally measured in the detectors

and what one wants to determine (the neutrino properties). One of the roles of the MC generators is to simulate the interaction between the neutrino (projectile) and the target nucleus (detector), typically: oxygen (from water), carbon (from mineral oils) and argon (liquid argon detectors).

The goals of this work will be:

1) Familiarization with different theoretical models for neutrino-nucleus interaction.
2) Familiarization with one or some of the MCs used by the community for the propagation of hadrons in the nuclear medium: cascade models, GEANT4, TOPAS, etc.
3) Implementation of one or some of the theoretical models in a MC event generator such as GENIE or NuWro.

This work might be continued into a PhD

16. Design of an advanced PET detector for verification of range in proton therapy - APP

Supervisor: Pedro Rato (CIEMAT), José Manuel Udías (UCM) pedro.rato@ciemat.es, jose@nuc2.fis.ucm.es

Proton therapy uses protons to radiate patients, because thanks to the Bragg peak allows obtain better dose compliance than photons or electrons. In Madrid two protontherapy facility have been built which will start their activities momentarily. The potential of Proton therapy is limited by uncertainties about the position of the Bragg peak in the patient, that is, by determining the range of protons in vivo. Thus, a very active research topic in the field is the in vivo verification of the range of protons, in particular by detecting PET activity (positron emission tomography) that protons produce in the patient during irradiation. This master project will optimize the design of a PET detector dedicated to the proton range verification, based on detector modules and electronics developed at CIEMAT. Monte Carlo simulation techniques will determine the detector performance (sensitivity, image quality) for different settings geometric detectors.

17. Application of Machine Learning and Neural Networks for Modeling Radiation Transport in Matter – APP

Supervisor: Joaquín López Herraiz (UCM) jlopezhe@ucm.es

The goal of this work is to use modern techniques of Machine Learning and Neural Networks to obtain a fast and precise model of the range of charged particles in heterogeneous matter. The neural network (NN) will be based on Tensorflow and Keras using Google Colab. The student will first learn the basic concepts of these methods. The NN will be trained using realistic Monte Carlo simulation codes commonly used in Nuclear Physics (Geant4, MCNP, TOPAS, PENELOPE). After the training, it will be evaluated both with simulated and real data. Applications in nuclear medicine and protontherapy will

be considered.

This work can be continued to pursue a PhD thesis. No funding for a PhD position is currently available, although fellowships and grants may be available in the future.

18. Application of Machine Learning and Neural Networks in Nuclear Physics - APP

Supervisor. Joaquín López Herraiz (UCM) jlopezhe@ucm.es

The goal of this work is to use modern techniques of Machine Learning and Neural Networks to obtain nuclear parameters from the experimental data measured in different radiation detectors. The neural network (NN) will be based on Tensorflow and Keras using Google Colab. The student will first learn the basic concepts of these methods. The purpose is to explore how much additional information can be extracted with these techniques and go beyond the performance of standard procedures. The student will work with real data acquired in experiments in Europe and USA. Applications in nuclear medicine and radionuclides detection will be considered.

This work can be continued to pursue a PhD thesis. No funding for a PhD position is currently available, although fellowships and grants may be available in the future.

19. INSTRUMENTATION AND MC SIMULATION TO IN-BEAM REAL TIME MONITORING OF DOSE DEPOSITION IN HADRONTHERAPY - APP

Supervisor: Luis M. Fraile (UCM), José Manuel Udías (UCM)

Contacts: lmfraile@ucm.es jose@nuc2.fis.ucm.es

At least two clinical protontherapy beamlines will begin beam delivery early 2020 in Madrid. Within this MSc project instrumentation for real-time in-beam monitoring of dose delivered by hadrons would be developed, either by means of prompt gammas as well as prompt PET emission. The Nuclear Physics Group of Complutense University in Madrid has massive experience in the development of gamma detectors with state of the art spatial, energy and time resolution, and being based on SiPM, they are compatible with magnetic fields. The group exhibits a long standing collaboration with the company SEDECAL in Madrid that develops and sells nuclear imaging equipment all over the world and it is also involved in this project. The MSc project would be involved in MC simulations of the detectors, in the actual detector development in our lab, as well as in image reconstruction of dose delivery

http://nuclear.fis.ucm.es

This Master project might be continued into a PhD.

20. Gamma-MRI, a new molecular imaging technique - APP

Supervisor: Luis M. Fraile (UCM), José Manuel Udías (UCM) lmfraile@ucm.es, jose@nuc2.fis.ucm.es

A new imaging technology, termed originally Polarized Nuclear Imaging (PNI) and also noted as gamma-MRI, was recently unveiled in an research letter to Nature by the group of Gordon Cates at the University

of Virginia(1). They successfully demonstrated that gamma decay anisotropy from polarized nuclei could be magnetically manipulated to create a 3D image, in a manner similar to magnetic resonance imaging (MRI). The major breakthrough of this image modality is that it combines the extreme spatial resolution of MRI with the detection sensitivity of gamma cameras and PET scanners. If this technology is developed to its full potential, the major limitations of both MRI (sensitivity) and PET (resolution) will be overcome in one modality. This γMRI project will develop a detailed simulation of all steps involved in designing a working prototype for preclinical in vivo molecular imaging based on a revolutionary technology. Development of novel gamma detectors suitable for this technology will be also considered.

[1] Zheng Y, Miller GW, Tobias W A, Cates G D. Nature 537 (2016): 652

This Master project might be continued into a PhD.

Master thesis proposals in GSI Helmholtzzentrum für Schwerionenphysik GmbH for 2019-2020

21. Heavy-ion tracking detection systems for studies of reactions with relativistic rareisotope beams - APP

Supervisor: Prof. Dr. Thomas Aumann - Email: T.Aumann@gsi.de

We are operating a newly developed experiment for kinematically complete measurements of reactions with relativistic radioactive beams (R3B). Goal of our research is the understanding of the properties of exotic short-lived nuclei and their reactions. For an unique characterization of the final state, the properties of emerging heavy fragments have to be determined precisely after the reaction by measurements of their trajectory through a magnetic dipole field, their energy-loss and their velocity. From the combined information, the fragment momentum can be determined with a relative resolution of dp/p=10-3.

In this Master-Thesis project, scintillating-fibre detectors with Si-photodiode readout for position measurements will be tested, optimized, and characterized from in-beam measurements. The detectors will be used in beam times end of 2019 and beginning of 2020.

https://www.gsi.de/work/forschung/nustarenna/nustarenna_divisions/kernreaktionen.htm

22. Binding energies of atomic nuclei - ultimate mass accuracy of MR-TOF-MS - APP

Supervisor: Dr. Timo Dickel Email: t.dickel@gsi.de

The mass of an atomic nucleus is one of its key information, it gives insight to its inner structure e.g. to pairing or shell effects. At the FRS Ion Catcher at GSI, a multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) with world-wide unique performance characteristics has been developed. The MR-TOF-MS can perform high precision direct mass measurements of short-lived exotic nuclei. To achieve highest mass accuracies a laser ablation carbon cluster ion source is coupled with the MR-TOF-MS to provide calibrant ions over a broad mass range produced at the repetition frequency (≈ 100 Hz) of the MR-TOF-MS. In this project, the commission the laser ablation source shall be completed and

systematic measurements investigating the achievable mass accuracy of the MR-TOF-MS (in the range of 1E-8 or even less) shall be done.

https://www.gsi.de/work/forschung/nustarenna/nustarenna_divisions/frs_super_frs.htm

23. Proton radioactivity of nuclei at the limits of stability - Monte-Carlo simulations of exotic nuclear decays - APP

Supervisor: Dr. Ivan Mukha Senior Researcher Email: i.mukha@gsi.de

The EXPERT group is preparing and performing experiments, which are devoted to the study of so-called proton radioactivity, which is a certain mode of radioactive decays of atomic nuclei, which was discovered a few years ago. The approved experiments ``Four proton decay of 18Mg´´ and ``Search for two-proton radioactivity of 26S´´ are planned at the FRS magnetic spectrometer of GSI. We offer to participate in the preparations to the forthcoming experiments (and participation in the experiments when running) by performing Monte-Carlo simulations of the EXPERT-setup response to exotic nuclear decays in flight by using the GEANT4 simulation package from CERN. Such simulations have already been started where the correlations between the decay products (heavy ion and proton(s)) are analysed taking into account both, the transverse momentum (emission angles) and the longitudinal momentum, yielding more refined decay results when the second half of the (Super-)FRS is used as high-resolution spectrometer.

https://www.gsi.de/work/forschung/nustarenna/nustarenna_divisions/frs_super_frs.htm

Master thesis proposals in CSIC for 2019-2020

24. R&D on New technologies for Nuclear Security - APP

Supervisor: Olof Tengblad olof.tengblad@csic.es

One of the possible practical use of scintillator detectors is for early warning systems, where one would like to know if the radioactivity is deposited on the ground or is still airborne.

One aim would be to mount such a detector system on a drone. The detector should be equipped with readout electronic and ADC, it should preferably be small, lightweight and autonomous.

The system is to be equipped with a computer of small size with built-in GEO and TIME-stamping including wireless communication to a base station. The computer found for this purpose is the Raspberry Pi3. It is a programmable device, with Linux as the default operating system. It can be equipped with peripherals such as a camera, GPS and incorporates wireless LAN and Bluetooth connectivity, it is small 8x6x2 cm, low operating voltage (5V) and low weight. The Raspberry Pi comes with pre-installed libraries to access the IO using Python, C or C++.

The detected signals should be digitized by the ADC, controlled by the computer and transmitted over a wireless LAN to the base station.

The Master Thesis proposed is to put together and program the equipment in order to obtain a working autonomous prototype.

Master thesis proposals in CENESTEN (Rabat – Morocco) for 2019-2020

25. Measurement radionuclide activities in different matrices by alpha, beta and gamma spectrometries. - APP

Supervisor: Abdelmourhit LAISSAOUI, laissaoui@cnesten.org.ma

Objective: to develop capacities in term of monitoring of radionuclide concentrations in the environment food.

Numerous sources of ionizing radiation can lead to human exposure: natural sources, nuclear explosions, nuclear power generation, use of radiation in medical, industrial and research purposes. Before assessing the radiation dose to a population, one requires a precise knowledge of the activity of a number of radionuclides in different matrices.

Sub-topics to be covered:

- Detailed requirements for installation of laboratories devoted to samples preparation, radiochemistry, counting, etc… reagent storage, equipment maintenance and radioprotection;

- Alpha spectrometry and gamma spectrometry: Determination of natural and man-made radionuclide activities (radiochemistry, alpha acquisition, spectra treatment and activities calculations and uncertainties, Quality control procedures). Samples could be environmental samples (soil, sediment, water and biota), food stuff samples and ore samples;

- Liquid Scintillation Counting: Determination of gross alpha/beta radioactivity in drinkable waters; determination Sr-90, H-3 and C-14 activities in environmental samples.

26. Evaluation of soil erosion in forestry and agriculture using Cs-137 and Be-7 radioelements - APP

Supervisor: Abdelmourhit LAISSAOUI, laissaoui@cnesten.org.ma

Objective: To study the impact of soil conservation practices and climate change on soil degradation.

Combating soil erosion requires investment and, due to the often limited resources, it should be targeted in critical areas and time period. Therefore, comprehensive knowledge of spatial and temporal variability of erosion processes is urgently needed. Most conventional methods do not provide information on the spatial distribution of erosion. Isotope tracers can help meet these deficiencies as some radionuclides occurring in the environment can serve as environmental tracers and hence facilitate the investigation of these landscape processes. The soil erosion rates can be estimated using 137Cs, a human-induced radionuclide of caesium released into the atmosphere during nuclear weapon tests more than half a century ago. The 137Cs method for soil erosion assessment effectively provides long-term mean soil redistribution rates, representing the period since its release (mid-1950s) until the time of the 137Cs sampling.

- Work to be done:

* Sampling strategy: selection of study sites and reference sites

* Sampling of soil samples, sample pre-treatment and conditioning

* Analyzes of radioelements in the laboratory (gamma spectrometry using High Purity Germanium Detectors, efficiency calibration, energy calibration)

* Establishment of the depth profiles of Cs-137 and Be-7 and calculation of the inventories (Bq / m2)

* Using conversion templates

* Data processing and interpretation

* Writing of the report