ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Study of exotic nuclei via beta decay with GRIFFIN

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ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The GRIFFIN array at TRIUMF, Canada, is currently the state-of-the-art decay spectrometer, with one of the highest gamma-ray efficiencies and a suit of ancillary detector that allows for in-depth decay experiments. It is routinely used to study the structure of some of the most exotic isotopes with extreme neutron-to-proton ratios.

What are you going to do? The master research project will consist of the data analysis of recent GRIFFIN experiments. You will analyze the beta decay of exotic nuclei and build their level schemes, making use of different nuclear physics techniques, such as angular correlations, conversion electron spectroscopy or ultra-fast timing.

What are you going to learn? During this work, you will familiarize yourself with GRIFFIN and TRIUMF, a world-leading laboratory. You will also learn to use powerful analysis tools like ROOT, the most commonly used software in the nuclear and particle physics field. Finally, you will gain in-depth knowledge about nuclear structure far from stability and a wide range of nuclear physics detectors, able to detect gamma rays or charged particles.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Beta decay experiments at ISOLDE, CERN

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ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The ISOLDE laboratory, at CERN, pioneered the development of radioactive beams, and it is still considered a world-class laboratory in nuclear physics. One of its experimental lines is the ISOLDE Decay Station (IDS), which is the permanent setup to conduct decay experiments of exotic nuclei, with a special focus on beta decay. The CSIC and UCM groups routinely use IDS to unravel the nuclear structure of isotopes far from the Valley of Stability.

What are you going to do? The master research project will consist of the data analysis of recent IDS experiments. You will analyze the beta decay of exotic nuclei, building their level schemes and measuring the lifetime of excited state in the picoseconds (10^{-12} s) range.

What are you going to learn? During this work, you will familiarize yourself with the fundamental aspects of decays experiments at IDS, and with the ISOLDE facility at CERN. You will also learn how to use powerful analysis tools like ROOT, the most popular software in the nuclear and particle physics field. Finally, you will gain in-depth knowledge about nuclear structure far from stability and a wide range of nuclear experimental techniques.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Microscopic description of particle-plus-rotor nuclei

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ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The structure of some nuclei with an odd number of particles (odd-even or even-odd number of protons-neutrons) can be understood as the motion of the unpaired particle and a rotating even-even core. One can distinguish some characteristic spectra depending on the strength of the interaction between the particle and the core.

Our goal in this Master's Thesis proposal is the description, from microscopic calculations where the individual nucleons are the actual degrees of freedom of the system, of the spectra obtained with the geometrical picture.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Structure of exotic N=Z nuclei with variational approaches

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ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Medium-mass N=Z nuclei are suitable systems to test several many-body phenomena, e.g., proton-neutron pairing correlations, multiple shape-coexistence or isospin symmetry breaking.
Additionally, some of these neutron deficient nuclei are of astrophysical interest because they could be waiting-points of rp-process and/or νp-process nucleosynthesis.
The theoretical description of these systems is still challenging, in particular, the calculation of their properties within a self-consistent mean-field and beyond-mean-field framework.
The aim of this Master's Thesis proposal is the study of even-even and odd-odd N=Z nuclei in the $28 < N (= Z) < 50$ region using a recently developed computer code (TAURUS) that implements those many-body techniques with realistic

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS

Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Alpha-induced reactions of astrophysical interest

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ABSTRACT

(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The master thesis will address production yields of reactions produced by alpha particles that play a role on astrophysical scenarios, with emphasis on (α,n) reactions. measurement and analysis of production yields of isotopes that gamma emitters that may be relevant for range verification in protontherapy. Measurements will be performed at the CMAM 5-MV in Madrid, focusing on online detection of gamma rays from (α,nγ) reactions and thick target yields by activation.

Alpha-particle induced reactions play an important role in nuclear physics and as well as in several applications. From the perspective of nuclear astrophysics, (α,n) reactions are of specific interest for the investigation of neutron sources for the slow neutron capture process, the production of radionuclides by energetic solar particles and the nucleosynthesis of light nuclei in the r-process, to name a few.

This master thesis proposes the study of the impact of selected alpha-induced reactions in nuclear astrophysics by experimentally investigating reaction processes of alpha particles on stable nuclei. Measurements will be performed at the CMAM electrostatic 5-MV tandetron accelerator at alpha energies up to 15 MeV, both online for (α,nγ) and other channels with the gamma array GARY, and offline to obtain thick target yields from activation measurements. The results will be compared to the available data and suitable reaction models.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS

Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Gamma and fast-timing spectroscopy of exotic nuclei around ^{132}Sn

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ABSTRACT

(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

This master thesis is devoted to data analysis of neutron-rich nuclei around the doubly-magic 132Sn populated in beta decay at the ISOLDE facility. Gamma spectroscopy techniques will be used to verify and expand the presently known level schemes, while the advanced time-delayed βγγ(t) (fast timing) method will allow to measure excited level lifetimes.

Substantial effort has been directed in the last decades to nuclear structure studies in the region around the neutron-rich 132Sn, one of the most exotic doubly-magic isotopes presently at reach. Nuclei in this area of the table of isotopes is of great of interest to test models and provide information about single particle states and on the development of collective effect close to a double-shell closure. The reduced electromagnetic transition probabilities connecting nuclear states are key to probe models in detail. They can be obtained from the measurement of excited level lifetimes.

This master thesis proposes the experimental investigation of nuclei in the region of ^{132}Sn using fast-timing and gamma spectroscopy. Data were acquired at the ISOLDE facility at the ISOLDE Decay Station equipped with highly efficient clover-type Ge detectors along with a compact fast-timing setup consisting on $LaBr_3$(Ce) detectors and a fast beta detector. The beta-decay of both exotic In and Cd nuclei were used to populate the excited structure of the nuclei of interest. Within the master thesis level schemes will be constructed and excited level lifetimes measured for selected Sb isotopes. A comparison with state-of-the-art theoretical calculations will be performed.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Reaction cross sections of interest for range verification in protontherapy

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ABSTRACT

(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The master thesis deals with the measurement and analysis of production yields and cross sections of PET isotopes and prompt gamma emitters that may be relevant for range verification in protontherapy. The measurements will be performed at the CMAM 5-MV tandem and the clinical Quirónsalud protontherapy accelerator, both in Madrid.

It is recognized that radiotherapy using protons and other hadrons offers dosimetric advantages over conventional radiotherapy techniques arising from the physics of energy loss by charged particles in matter. Protons deposit most of their energy in the Bragg peak, making it possible for enhanced dose delivery to target organs, while minimizing dose to healthy tissue. The flip side of the coin is that protontherapy is very sensitive to proton range inaccuracies, which may arise from errors in patient positioning, inaccurate conversion of linear attenuation coefficients used in CT scans to stopping power values, or anatomical changes during treatments.

Several proton range verification techniques are being explored to mitigate these effects and take protontherapy to its full potential. Among them Positron Emission Tomography (PET) is able to detect $ß^+$ isotopes generated by protons in the irradiated regions so that activation maps can be correlated to dose deposition. Prompt-gamma (PG) detection profits from prompt gamma emission from species created by proton impact. In human tissues prompt gamma and positron emitters are created by protons at the relevant clinical energies, but they may also be generated by proton interaction with administered contrast agents. Proton-induced reaction cross sections on both naturally present and contrast elements are relevant in a wide range of energies to properly characterize the production of PET and PG emitters and reduce uncertainties.

This master thesis will address the measurement of proton-induced yields and cross sections on natural tissues and on promising contrast agent materials, with the aim of characterizing the production of short-lived PET isotopes and prompt gamma radiation emitters. The measurements will be performed at the CMAM electrostatic tandetron accelerator at proton energies up to 10 MeV and complemented with measurements at the Quirónsalud protontherapy centre at clinical energies.