JOINT EUROPEAN MASTER IN NUCLEAR PHYSICS
Academic Year 2025/2026

MASTER THESIS PROPOSAL

TITLE: Design and construction of a cryogenic Penning trap for single-proton production and detection

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UNIVERSITY/RESEARCH CENTER: Universidad de Sevilla / Universidad de Cádiz

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

In this Master's thesis, the student will participate in the design and construction of a cryogenic Penning trap setup aimed at producing and detecting single protons, with potential applications within the BASE (Baryon Antibaryon Symmetry Experiment) collaboration. The experimental setup will include a two-stage cryocooler capable of reaching 4 K, a cylindrical Penning trap built with permanent magnets, and a detection system based on image currents induced in the trap electrodes. The student will be expected to use simulation and design software (AutoCAD Inventor, Mathematica, Matlab, SimION) and to develop experimental control routines in Python (ARTIQ). In addition, the project will involve small hands-on tasks in electronics, ultra-high vacuum systems and cryogenics. This work will be carried out at the Departamento de Física de la Materia Condensada of the Universidad de Cádiz, located in Puerto Real, Cádiz (Spain).

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2025/2026

MASTER THESIS PROPOSAL

TITLE: Detector developments towards dose monitoring in harsh radiation conditions via Compton imaging in radiotherapy

SUPERVISOR(S): Pablo Torres Sánchez, Jorge Lerendegui Marco, Carlos Guerrero Sánchez

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UNIVERSITY/RESEARCH CENTER:
Universidad de Sevilla (US) / Instituto de Física Corpuscular (CSIC-UV)

ABSTRACT

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

Detector development is gaining interest in medical physics, aiming to enhance current technologies and introduce new imaging and treatment techniques, particularly where commercial products are unavailable. This is the case for ion-range verification in hadron therapy (HT) and real-time dosimetry in boron neutron capture therapy (BNCT). Detectors with low neutron sensitivity and high-count rate capabilities are ideal for dosimetry in these treatments.

The i-TED Compton Camera Array, developed at our research group at IFIC for nuclear physics research [Dom16], is being adapted for medical use profiting from its low neutron sensitivity, larger efficiency and other technical aspects [Ler22, Tor25]. Key challenges include handling high counting rates, where segmented crystals offer an advantage, and handling high counting rates and intense backgrounds. New CLLBC and CeBr3 scintillators are under study in our group for these purposes, under test in laboratory and in experimental campaigns at neutron beam facilities. New advanced shielding designs, optimized for epithermal and thermal neutrons, and secondary gamma radiation, are also needed for operating the detectors in adequate conditions.

This Master thesis at IFIC will explore these challenges, incorporating experimental lab work and detector characterization; Monte Carlo simulation for detector design, and data analysis from experimental campaigns.

[Dom16] C. Domingo-Pardo, Nucl. Instr. Meth. A (2016)
[Ler22] J. Lerendegui-Marco *et al.* Sci. Rep. (2022)
[Tor25] P. Torres-Sánchez *et al.* Appl. Radiat. Isot. (2025)

JOINT EUROPEAN MASTER IN NUCLEAR PHYSICS
Academic Year 2025/2026

MASTER THESIS PROPOSAL

TITLE: Systematical optical model analysis on weakly bound nuclei reactions

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UNIVERSITY/RESEARCH CENTER: Department of Atomic, Molecular and Nuclear Physics

ABSTRACT

The main objective of this work is to introduce the student in the field of nuclear reactions data analyses. The work is based on systematic optical model (OM) analyses applied to different weakly bound nuclei projectiles reacting on different heavy targets [1-4]. Within data sets, we perform OM calculations and determine optical potentials (OPs). The OPs are based on the double-folding (DF) São Paulo potential (SPP) [5]. Within the SPP approach, our goal is to develop the so-called São Paulo Optical Model Protocol (SP-OMP). The SP-OMP is based on the determination of the OP (real and imaginary) strengths and their respective uncertainties. Within the SP-OMP, we are able to study the sensitivity of data to the OP, their dependence with energy and the correlation between the OP real and imaginary terms. In addition, we study the correlation of the OP with the binding energy of the projectile and its dissociation. Furthermore, we can determine optimum energies for which the projectile dissociation could be favored, as a function of the projectile breakup Q-value and the Coulomb barrier of the system. The capability of predicting on optimum projectile dissociation yields, as a function of energy, represents an important tool for understanding the role of nuclear structure in the dynamics of nuclear reactions. Moreover, it allows for planning new experiments on these weakly bound nuclei reactions. Finally, the determined OPs are of value for further microscopic coupled channel (CC) calculations on such nuclei reactions studies.

1) Phys. Rev. C **100**, 064602 (2019)
DOI: https://doi.org/10.1103/PhysRevC.100.064602

2) Phys. Rev. C **109**, 054608 (2024)
DOI: https://doi.org/10.1103/PhysRevC.109.054608

3) J. Phys. G: Nucl. Part. Phys. **52** 075102 (2025)
DOI: 10.1088/1361-6471/adeda6

4) Phys. Rev. C **111**, 034615 (2025)
DOI: https://doi.org/10.1103/PhysRevC.111.034615

5) Computer Physics Communications
Volume 267, 2021, 108061
DOI: https://doi.org/10.1016/j.cpc.2021.108061

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS

Academic Year 2025/2026

MASTER THESIS PROPOSAL

TITLE: Neutron capture experiments on radioactive isotopes for astrophysics at CERN n_TOF

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UNIVERSITY/RESEARCH CENTER:
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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).

Neutron capture cross-section measurements are essential for understanding stellar nucleosynthesis processes, particularly the slow neutron capture (s-) process occurring in red-giant and massive stars [1]. Our research group at IFIC, investigates challenging neutron-capture reactions of astrophysical relevance, employing radioactive isotope targets and high-intensity neutron beams at the CERN n_TOF facility [2].

The proposed project aims to conduct a comprehensive feasibility study on measuring neutron capture cross sections of radioactive nuclei of key importance for stellar nucleosynthesis at CERN n_TOF. The study will encompass the full design of future experiments, including the production of the sample of unstable isotopes, evaluation of the different neutron beams and measurement techniques. This project will aim at assessing the feasibility of performing such measurements at CERN in the recently upgraded time-of-flight station n_TOF-EAR2 [3] and the newly established activation station NEAR [4].

The student will gain familiarity with the main stellar nucleosynthesis processes driven by neutron capture reactions and the experimental techniques to measure these reactions, perform numerical calculations and Monte Carlo simulations using the CERN ROOT framework and the Geant4 toolkit. Last, the student will have the opportunity to get involved in the analysis of on-going neutron-capture experiments on the key s-process isotopes ^{79}Se and ^{135}Cs [5].

[1].- F. Käppeler, et al., *Reviews of Modern Physics 83, 157 (2011)*
[2].- C. Domingo-Pardo et al., *Eur. Phys. J. A 61, 105 (2025)*
[3].- J.A. Pavón-Rodríguez, J. Lerendegui-Marco, *Eur. Phys. J. A (in print)* (2025)
[4].- N. Patronis et al., *Eur. Phys. J.* A 61, 215 (2025)
[5].- J. Lerendegui-Marco et al., EPJ Web Conf. 329, 03003 (2025)