Facultad de Física

M. U. en Física Nuclear

Memoria de Verificación

2024-2025

SELF-EVALUATION REPORT

Version 04-07-2023

Name of the programme

Joint European Master Degree in Nuclear Physics

NucPhys

Name of the coordinating institution

University of Seville

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Glossary

Consortium. The 6 partner universities of NucPhys:

1. **USE**: Universidad de Seville, Spain (coordinator)
2. **UB**: Universidad de Barcelona
3. **UCM**: Universidad Complutense de Madrid
4. **UniCaen**: Université de Caen Normandie
5. **UniCT**: Università degli Studi di Catania
6. **UniPD**: Università degli Studi di Padova

Abbreviations:

- **EC**: European Commission
- **ECTS**: European Credit Transfer System
- **EEA**: European Education Area
- **EHEA**: European Higher Education Area
- **EIT**: European Institute of Innovation and Technology
- **EIT-OLOs**: EIT Overarching Learning Outcomes
- **EQAR**: European Quality Assurance Register for Higher Education
- **ERA**: European Research Area
- **EU**: European Union
- **HE**: Higher Education
- **HEI**: Higher Education Institutions
- **IH**: Innovation Hub
- **KICs**: Knowledge and Innovation Communities promoted by the EIT
- **LOs**: Learning Outcomes
- **MLOs**: Module Learning Outcomes
- **NGOs**: Non-governmental Organizations
- **NucPhys**: Joint European Master Degree in Nuclear Physics
- **PLOs**: Programme Learning Outcomes
- **QA**: Quality Assurance
- **QF-EHEA**: Qualifications Framework for the European Higher Education Area
- **RIS3**: Research and Innovation strategies for (regional) Smart Specialisation
- **SER**: Self Evaluation Report

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Introduction

NucPhys academic & research goals

The European Master Degree in Nuclear Physics started in 2017 with the solid intention of bringing together the best expertise and facilities all around Europe in order to prepare worldwide students to overcome present and future challenges of the field in its three different spatializations: theoretical, experimental and applied Nuclear Physics.

Nuclear Physics is a broad matter of relevance from both the fundamental knowledge of Nature and the multiple applications to different fields of strategic economical relevance. These include energy resources (based on fusion or fission), biomedical sciences, analysis and characterization of new materials, environmental studies (atmosphere, soil, waters), dating, art and archaeometry, airport and toll security, military applications, industrial automatization and control, fire surveillance, among others. There is a clear need to support the development of nuclear competences at the European level. However, there was no international teaching programme in Europe at the Master level devoted specifically to Nuclear Physics before NucPhys. Nevertheless, most of them are designed in combination with particle physics and/or nuclear technology and thus they do not provide the fundamental basis and a profound knowledge in nuclear physics.

The present project was born with the intention to educate Nuclear Physicists at the highest international level. Such a highly specialized curriculum, by definition, can only be addressed to a very restricted number of students in a few universities. For this reason, most European University centers include Nuclear Physics only as a specialization embedded in a larger and more generic curriculum including other branches of Physics. Thus, only relatively generic and interdisciplinary Master Courses called “Physics”, “Science”, "Nuclei, Atoms and Collisions", "Particles and Nuclear Physics" or "Advanced Physics" are found in most European Universities. This situation had clearly a detrimental effect on the visibility of Nuclear Physics as a well-defined branch of Physics with important theoretical, experimental and applied implications. An exception was the case of Spain, where the University of Seville coordinates a specific joint Master Degree on Nuclear Physics, with the participation of other five Universities (Autónoma de Madrid, Barcelona, Complutense de Madrid, Granada, and Salamanca). This Master Course has been running during the last decade with excellent results.

With this experience, we created a new and stronger international consortium by adding University of Padova, University of Catania and University of Caen-Normandie, who brought high-experienced researchers and top-level nuclear physics facilities. With these partners, we now offer a complete programme including theory, experiments and applications, covering all different aspects of the nuclear field. Hence, the consortium offers a highly specialized curriculum in the form of a joint European Master Course on Nuclear Physics (NucPhys).

This consortium is strengthened with the participation, as associated partners, of most of the large facilities for nuclear physics worldwide, as well as hospital and companies. Initially, these associated centers were located in Europe. Once the consortium has been consolidated, it is being expanded with the addition of new international partners from all the continents to be able to reach any interested student in nuclear physics all around the world. In the last years, the network of associated partners has been expanded through the addition of new collaborations with institutions from America, Asia and Africa.

The present proposal aims at continuing to develop a 120 ECTS long-lasting international joint study programme, "European Master in Nuclear Physics" (NucPhys), this time as a joint degree, to educate experts in the field of Nuclear Physics, in order to meet the needs of this sector.

NucPhys first edition in 2017 received more than 70 applications, while this number reached 121 in the second intake and 150 for the third intake. This number of applications has been constant over the years. This attests to the relevance of our programme and encourages us to continue developing NucPhys, taking corrective actions that will ensure its excellence and adapt to the needs of a sector that is fast evolving. Along this journey, the programme has been funded twice through the Erasmus+ programme for Erasmus Mundus Joint Masters (EMJM).

The main objective at the end of NucPhys is that participants will have advanced knowledge with a first research/working experience in the Nuclear Physics field. This will directly enable them to successfully perform doctoral studies or to be inserted in research/working teams in Scientific Centers/Companies/Industries/Medical Centers/etc. Students of NucPhys are trained in nuclear technology, safety and radiation protection. The proposal addresses the integration of students in the industry and other institutions (i.e. hospitals), and seeks to bring young researchers into Euratom-supported research projects. The aim is to respond to the needs of the nuclear industry and the corresponding regulatory bodies. Also important are the so-called nuclear activities of proximity, which include medical applications, the relevant non-nuclear industrial applications and the transport of radioactive materials. In line with the strategy for EU international cooperation in research and innovation (COM(2012)497), international cooperation is fundamental and is the basis of this proposal.

The creation of the Nucphys consortium specially designed to integrate the best expertise (needed to create an assembled, well-based and complete programme) was a necessary step forward to achieve these objectives, because none of the mentioned institutes could alone offer a complete study career that covers all aspects of this multi-faceted field.

It is important to note that we propose three specialization paths (see below for details) so as to cover all branches of Nuclear Physics. In path 1, (experiments and instrumentation in large accelerators) students are in contact with forefront nuclear physics experiments and with the companies working in the field (electronics, vacuum, electromagnetism, new materials, etc.). In path 2 (theoretical), students will learn more academic topics related to fundamental interactions and components of matter. In path 3 (applications and small accelerators), students will learn about many applications of nuclear physics, in particular: material analysis, therapy (including the new hadrontherapy), archaeometry, medical imaging, etc. They will be also in contact with companies developing instrumentation for applications. These three lines cover both, academic and professional important aspects for the future of the nuclear physics young generations.

We would like to emphasize that it is extremely important to ensure a high-level competence in both fundamental and applied nuclear science, at the EU, national, and regional levels because:

Nuclear science and technology have many applications. Nuclear fission is the splitting apart of the nucleus of an atom. By carefully controlling this process at an industrial scale, we can harness the large quantities of energy released to generate electricity for the benefit of society as a whole. In this way, for about three decades, civil nuclear power stations in a number of European countries have been responsible for producing approximately one-third of all the EU's electricity. Concerning the specific French context, nuclear power is its first source of electricity production. The politics of the country is to allow a controlled development of nuclear energy, develop new and safer reactors, and contribute to waste recycling, dismantling old nuclear plants in the deepest respect to strict security rules. Nuclear Physics has other applications apart from energy production. For example, radiation is used extensively in medical diagnostic and therapeutic practices,

such as imaging (e.g. X-rays), cancer radiotherapy or radioactive tracers. Most radioisotopes and radio-pharmaceuticals are produced in small nuclear reactors, which also serve as research facilities.

The importance of nuclear research at the European level is testified by the Nuclear Illustrative Programme presented under Article 40 of the Euratom Treaty in May 2017 by the European Commission. It states that, retaining technological leadership in the nuclear field is possible only if interested Member States maintain diverse and sufficiently funded nuclear research capabilities, including education and training aspects. Continuing to pursue research and development is instrumental to maintain the EU at the forefront of nuclear technology and develop the highest standards of safety, security, waste management and non-proliferation. This implies continued investment on research and training/education, as well as on nuclear research infrastructure.

The EU-funded programme of research also contributes to these efforts. Key thematic areas of interest include safe long-term management of radioactive waste (including disposal as well as technologies to reduce and recycle hazardous material), nuclear installation safety, the design of more efficient and sustainable nuclear reactors, and the risks of low and protracted exposure to ionizing radiation. This will allow Europe to maintain world leadership in nuclear safety and waste management and to attain the highest level of protection from radiation. Among other applications, the Programme will be carrying out research in the medical uses of radiation, for the benefit for all European citizens.

In particular, the Euratom Research and Training Programme that complements Horizon 2020 in the field of nuclear research and training, puts a strong emphasis on developing nuclear skills and competence. Its general objective is to support nuclear research and training activities. Specifically, point E of the Euratom Work Programme 2016 – 2017 (European Commission Decision C (2015) 6744 of 13 October 2015) is devoted to: E - SUPPORT THE DEVELOPMENT OF NUCLEAR COMPETENCES AT EU LEVEL. This action aims at addressing the difficulties encountered with maintaining and renewing an adequate number of well-educated and trained nuclear researchers and professionals, especially in view of expected high retirement and low renewal rates in countries with a strong nuclear tradition and of the growing need for further specialized training in emerging nuclear energy countries.

Moreover, the importance of nuclear research at the European level is testified by several independent agencies. It is important to mention the position papers of the European Physical Society (EPS) "Energy and Environment" (https://cdn.ymaws.com/www.eps.org/resource/resmgr/policy/eps_pp_energy_env_2009.pdf)
and "Energy for the future: the Nuclear option"(https://cdn.ymaws.com/sites/www.eps.org/resource/resmgr/policy/eps_pp_option_2007.pdf).
In addition to these industrial applications, fundamental nuclear science is a lively and active field. On the other hand, NUPECC, which is one of the Expert Committees of the European Science Foundation, stated in its latest Long Range Plan (https://www.esf.org/fileadmin/user_upload/esf/Nupecc-LRP2017.pdf) “These fascinating topics in basic science require concerted efforts in the development of new and increasingly sophisticated tools such as accelerators and detectors. It is important to emphasise that knowledge and technical progress in basic, curiosity-driven nuclear physics has significant societal benefits including the training of a highly skilled workforce and broad applications in industry, medicine, and security.” and in its 2010 one (http://www.nupecc.org/roadmaps/lrp2010_rec.pdf), "Europe should continue to be at the forefront of promoting one of the most vigorous and fascinating fields in basic science, Nuclear Physics. Nuclear Physics addresses the fundamental aspects of those particles that interact via the strong interaction. These hadrons constitute nearly 100% of the visible matter in the universe. With the renewed worldwide interest in nuclear technology (low-carbon energy: nuclear fission

and nuclear fusion power generation; nuclear medicine: imaging and tumor therapy, security, materials studies with nuclear probes, etc.), Europe needs to preserve, and even enhance, its nuclear physics knowledge and skills basis in the future. A dedicated effort directed at the training of young people is mandatory." Thus, the formation of new generations of nuclear physicists is of fundamental importance for Europe to keep and improve its leadership in this critical field. The importance for Europe to have a top-level community of Nuclear Physicists is clearly stated in this document.

In agreement with the NUPECC recommendation, several large-scale rare ion beams facilities have been approved or are already finished or under construction: SPIRAL2 in GANIL-Caen France, FAIR in Darmstadt Germany, SPES in Legnaro-Padova, Italy, ELI-NP in Romania (all of them associated partners of our consortium). Because of this extensive research activity at the European level, many employment offers at the PhD or post-doctoral level are presently available, which often do not find competent candidates to be filled. For this reason, the existence of a European Master programme in Nuclear Physics is strongly needed to ensure the proper education of the next generation of professionals in this field. To illustrate this point, let us mention that around 80% of our students obtain employment in the first three months after finishing, mainly in PhD programmes worldwide.

NucPhys Consortium

All the participants in the consortium have well known research groups in different and complementary aspects of Nuclear Physics and, in addition, teaching experience at the level of under- and post-graduate studies. In each consortium node, more than 10 scholars are permanent staff members of the local universities and internationally recognized experts in the field. Together with the scientists working in the different research labs associated to the consortium, they naturally guarantee the excellence of the teaching and tutoring. As mentioned in the preceding section, the origin of this project is the Erasmus Mundus Master Degree in Nuclear Physics that is already running from 2017. All Spanish Universities/Centers involved have important active groups in Nuclear Physics at theory (Seville, Complutense de Madrid, and Barcelona), experiment (Complutense de Madrid, Seville, CIEMAT, CSIC Madrid and Valencia) and applications (Complutense de Madrid, CIEMAT, Seville and Barcelona). What clearly lack are large scale Nuclear Physics facilities at European level. Thus, the consortium is completed with three important European Universities with active Nuclear Physics research groups in experiments, theory and applications and with strong links to key Nuclear Physics laboratories:

University of Caen-Normandie (UNICAEN), founded in the XVth century, hosts nowadays 30 000 students in different branches. Its key feature in the context of the present project is twofold. First, its close links with GANIL. GANIL, including the high intensity rare ion facility SPIRAL2 under construction, is one of the four largest laboratories in the world dedicated to research using ion beams. SPIRAL2 is complemented by two equipment of excellence (EQUIPEX), the next-generation spectrometer S3 and the experimental room for physics at low energy DESIR, both selected and financed by the National Agency of Research (ANR), led by the French Ministry of Higher Education and Research. Since the very beginning, GANIL has actively participated in European projects in which it cooperates with many laboratories from the European Union and beyond. (http://www.ganil-spiral2.eu/). In addition, Caen University is also strongly linked to the project ARCHADE (resource and research center in hadrontherapy) open in 2019. This center will have two independent superconductor cyclotrons: a protontherapy cyclotron for treatment, and a C400 cyclotron for ion acceleration up to Carbon for research purposes in hadrontherapy (physics, radiobiology and clinic aspects). The physicists implied in the Consortium are responsible of

the research programs in physics at ARCHADE as well as in the interdisciplinary programs for radiotherapy treatments.

University of Padua has a long and well established history in Nuclear Physics research which is strongly related to the Laboratori Nazionali di Legnaro (LNL) that is one of the four national labs of the Italian Institute of Nuclear Physics (INFN). The mission is to perform basic research in nuclear physics and nuclear astrophysics, together with applications of nuclear technologies. More than 800 scientists from all over the world are involved in the ongoing research programs. Every day about 250 people work at LNL, half of them being INFN employees (physicists, engineers, technicians....) the remaining half coming from universities and research institutions in Italy and abroad. The laboratory budget is nearly 20 Million Euro per year, half for handling and research, and half for personnel. Strength points are the development of particle accelerators and of nuclear radiation detectors. LNL have been recognized at European level as a Research Infrastructure with Transnational Access. (http://www.lnl.infn.it/). In addition, the Nuclear Research groups of Padova University have expertise on nuclear structure at the limits of spin and isospin, nuclear reaction dynamics at low, intermediate and ultra-relativistic energies, nuclear astrophysics and civil security applications of nuclear physics. Padova is a 800 year old institution with a long standing tradition for scientific excellence and a commitment to freedom and diversity.

University of Catania is one of the first Universities in Italy, founded in 1433. It is closely related to the Laboratori Nazionali del Sud (LNS). LNS is one of the four national laboratories of INFN. Founded in 1976 it currently employs about 130 people (researcher and technicians) and associates about 130 people among professors, researcher, PhD and Diploma students from the University. It is an advanced development center for technology and instrumentation. The laboratory budget is about 12 Million Euro per year for direct research, personnel budget excluded. The research activity is mainly devoted to the study of structure and reaction of atomic nuclei by mean of both a Tandem and a Supeconducting Cyclotron, in collaboration with more than 700 researchers coming from Italy as well as several European and non-European countries. A Tandem accelerator allows an intense activity in Nuclear Astrophysics measuring the cross section of interest for fusion nuclear energy and stellar nucleosynthesis (ASFIN2 project). Among the new projects in fundamental research it is also worth mentioning the construction and operation of a submarine cubic kilometer telescope (KM3NeT) installed at 3500 m depth offshore from Catania, with a long and complex R&D activity in which the LNS have been deeply involved inside the KM3NeT project (https://www.lns.infn.it/en/research/astroparticle-physics.html). UniCT and LNS beyond the experiments at the frontier of the Nuclear Physics are strongly active in several aspects of Applied Nuclear Physics such as accelerators technology, cultural heritage and Archaeometry with non –destructive techniques (LANDIS and PH3DRA labs), monitoring of Nuclear Waste, Laser Physics for Nuclear Fusion plasma and above all in Nuclear Medicine with a center for eye-melanoma therapy and the projects CATANA, ELIMED, SCENT. The students of NucPhys will be allowed to profit also from an on-going agreement between LNS and Azienda Ospedaliero Universitaria Policlinico di Catania to have a direct experience of applied nuclear medicine.

In the Spanish part of the consortium:
University of Seville: will act as coordinating institution and has experience on these issues since is already coordinating the running Erasmus Mundus Master Degree and also the Spanish inter-university Master Degree. Today is the one of the largest Spanish Universities with a number of students around 70000. it currently employs about 7000 people (including teaching staff, researchers and technicians). It provides, in addition to the coordination, scholars experts on theoretical nuclear reactions, applications Nuclear Physics to Environment, Medicine, Art and Archeometry, and analysis and characterization of Materials.
Facilities: CNA with three ion accelerators: Tandem Van de Graaff 3MV, Cyclotron with protons up to 18 MeV and deuterons up to 9 MeV and a Tandem Cockcroft-Walton of 1 MV used as mass

spectrometer. In addition, there is a scanner PET/CT for humans, a dedicated accelerator for 14C dating MiCaDaS, and a 60Co irradiator. (http://acdc.sav.us.es/cna/index.php/en).

University of Barcelona: Scholars experts on many-body problems, theoretical astrophysics and hadronic physics. It was founded in 1450. Presently it has more that 50000 students and around 8000 people in the teaching staff.
Facilities: ALBA is a facility co-financed by the Spanish government and the Catalan government. It is a new generation of synchrotron. ALBA is a circular-shaped machine, called a synchrotron that uses arrays of magnets, called insertion devices to generate bright beams of synchrotron light. There are research lines on: Accelerator Computing, Engineering, Experiments on material science mainly. (https://www.cells.es/)

University Complutense of Madrid: Scholars experts on theoretical nuclear structure, experimental nuclear physics, applications of nuclear physics to medicine and energy sources. UCM was founded in 1822. It is a large University with around 70000 students and 6000 people in the teaching staff. In 2009 the Ministry of Education awarded the highest mention "International Campus of Excellence (IEC)" to UCM.
Facilities: close connections to **CIEMAT** (Centro de Investigaciones Energ.ticas, Medioambientales y Tecnológicas) which is a public research body assigned to the Ministry of Economy and Competitiveness focusing on energy and environment and the technologies related to them. Of particular interest for NucPhys is the Thermonuclear Fusion Device TJ-II which is a heliac-type stellarator, which produces magnetically-confined fusion plasmas. (http://www.ciemat.es/).

We have summarized some of the main parameters of the different consortium universities in table 1. This table includes the number of students, administrative staff, academic staff and research centres of the six universities.

It is worth noting that all institutions are already collaborating in the development of the running Erasmus Mundus Master in Nuclear Physics. The collaboration is excellent from both academic and administrative points of view. In addition, the lecturers/researchers have previous research links: Seville-Caen-Complutense are already together in the project EURO-LABS that is the integrating activity for European nuclear scientists who are performing research in three of the major subfields defined by NuPECC: Nuclear Structure and Dynamics, Nuclear Astrophysics and Nuclear Physics Tools and Applications. Common projects between Barcelona-Catania (equation of state), Seville-Padova-Catania (nuclear structure and reactions and lately double-beta decay) have been active for many years. These links have been strengthened with the running Erasmus Mundus Master that has allow to sign mobility Erasmus Agreements at the level of Bachelor and post-graduate studies (Seville-Catania, Seville-Padova, Caen-Padova, Caen-Catania, Seville-Caen) that are presently active.

NucPhys fully benefits of the complementary specializations of the partners. Padova, close linked to Laboratory Nazionali di Legnaro, a large nuclear physics facility, have the academics/researchers and the experimental facilities to provide the appropriate background on experimental nuclear physics to students in path 1. Catania, closely linked to Laboratori Nazionali del Sud, an important facility for nuclear physics applications, will guarantee students in path 3 the appropriate specialization. The presence of the two national labs LNL and LNS make Padova and Catania ideal sites for the accomplishment of the Master thesis in experimental nuclear physics and the associated instrumentation. Spanish expertise in theoretical physics will provide with excellent teaching for the path 2 students. In addition, there are in Spain medium size facilities that will guarantee the appropriate development of nuclear physics applications oriented master thesis projects. The academic completeness of the curriculum for each specialization will be guaranteed by the Caen partner. Indeed, the triple connection to GANIL, ARCHADE and TALENT makes Caen

the ideal site for the third semester of the Master programme, dedicated to the specialization either in fundamental (theory and experiments) or in applied physics. With the present scheme Caen will be able to host Master Thesis in large facilities (GANIL), but also in theory and applications.

It is important to stress that a central, though not unique, issue to the Master degree will be the preparation of a PhD. All the labs associated to NucPhys in France, Italy and Spain are attached to doctoral schools for the preparation of PhD and will provide a natural job opportunity for our students. In addition, the associate member **HGS-HIRe** is a common graduate school of the universities Frankfurt Darmstadt, Giessen, Heidelberg and Mainz together with GSI and with many ongoing programs on Nuclear Physics. **GSI** operates a worldwide unique large-scale accelerator facility for heavy ions and currently employs about 1.100 people. In addition, approximately 1.000 researchers from universities and other research institutes around the world use the facility for their experiments. In the coming years the new international accelerator facility FAIR, one of the largest research projects worldwide, will be built at **GSI**. (https://www.gsi.de/en/). **CERN, TRIUMF, ELI-NP, RIBRAS, TANDAR, iThemba LABS** and many other facilities are associated members of the consortium that are helping us with master thesis proposals and extra-curriculum internships. See Table 2 for the number and distribution of the different associated partners.

The curriculum has been designed coordinately by all members in the consortium taking into account the expertise of the different nodes. Also, the previous experience has convinced the consortium of the convenience of having a common first semester (S1) with general matters so as to bring all students to an initial even level of knowledge. This S1 semester will be lectured in Seville as coordinating institution. This will allow doing all administrative tasks relative to inscriptions, visas, etc., in a centralized way from the beginning. Then in S2 starts the specialization: path 1 in Padova taking advantage of LNL and the academics and facilities related to large accelerators, path 2 in Spain using the strong theory groups in Madrid, Barcelona and Seville, and path 3 in Catania taking advantage of LNS and the AOUP (Azienda Ospedaliero-Universitaria Policlinico di Catania) with academics and facilities related to many Nuclear Physics applications. In S3 all students move to Caen, in which there are large scale nuclear physics facilities, GANIL, but also an important theory group and many industries/laboratories around that are associated members of this Master and guarantee the appropriate internships in S3. In addition, in S3 is programmed the highly specialized common course. The topic is selected each year among the hot topics in Nuclear Physics. For this common meeting on a specific relevant topic, selected scholars will be invited, and they are essential for the development of the course. Since the topics will be diverse the invited scholars provide an extra added value to the Master allowing us to have as lecturers the best specialists in the selected topic every edition.

Table 1. Nucphys facts and figures

	USE	UNICAEN	UniPd	UniCt	UB	UCM	TOTAL
Founded	1505	1432	1222	1434	1450	1822	
Scope[1]	COMP	COMP	COMP	COMP	COMP	COMP	
City Country	Seville SPAIN	Caen FRANCE	Padua ITALY	Catania ITALY	Barcelo-naSPAIN	Madrid SPAIN	
Language	Spanish	French	Italian	Italian	Spanish	Spanish	
Students	70.725	31.903	65.936	39.265	57.224	68.872	333.925
Technical and Admin-istrative Staff	2.936	1.232	2.346	1.128	2.461	3.308	13.411
Academic Staff faculty	4.440	1.571	2.268	1.216	6.119	6.521	22.135
Faculties & Schools	26	12	32 De-part-ments grouped into 8 Schools	17 De-part-ments	16	26	129
Research centres	12	10 Federa-tive bodies	25	35	16	9	107

[1] COMP (Comprehensive), TECH (Technical), UAS (University of Applied Sciences)

Table 2. NucPhys Associated Partners

	Associated Partners
Research Centers	27
Enterprises	3
Others	3
Europe	25
Africa	2
America	6
Total	**33**

Figure 1. NucPhys Consortium

Main objectives in jointness and integration elements of NucPhys

NucPhys Consortium was designed with a "jointness" basis that ensures coordination in the programme implementation in all stages of NucPhys:

A highly integrated consortium with partner organizations and associated members: Consortium and associated partners have cooperated in the programme design and in the implementation in all stages of NucPhys. These include designing the integrated programme (with compulsory mobility bringing added value to the programme), and the development of joint and integrated management (the Academic Committee), and assessment (the Quality Committee) structures, where students are also included. In addition, our more than 30 associated partners offer to students a plethora of placements opportunities and collaborate in the supervision and assessment of internship and Master Thesis. To our knowledge, no other comparable project exists worldwide.

The integrated programme of study, within which the consortium members recognize fully all courses delivered by the partners. Though based on the specificities of the different partner universities, NucPhys proposes a coherent, unified and progressive curriculum at the European level. It combines jointly developed academic provision and training with three specialization tracks and professional/research internships, visits to nuclear physics research facilities, distinguished visiting scholars, as well as a common high specialized course in a relevant topic selected by the Academic Committee in each intake. A specific effort is taken for the homogeneity of the training in the different institutions, allowing student mobility to each partner country.

The high specialized course (in Module 3) is a key element of the programme. To increase the academic quality of the course, the Academic Committee invites renowned scholars in the field of Nuclear Physics to give lectures or seminars. Important members of relevant companies are also invited to contribute with the industrial vision on several issues covered by the study programme.

Global objectives:

The integration of NucPhys students in the local environments. Although the Programme language is English, local language courses are offered for free to students. In addition, integration of local or other international students in selected modules promote "jointness" between these and NucPhys students.

The harmonization and recognition of awarded degrees. At present, the Spanish Universities have an accredited joint degree (and joint Diploma Supplement), and the Italian and French Universities can issue National accredited degrees, together with the corresponding Diploma Supplements (multiple degree choice). To improve this situation, the present evaluation through the European Approach Framework for Quality Assurance will hopefully take us towards the implementation of the Joint Degree.

The shared knowledge and consistent teaching and management practices between Universities. These include the integration of all the information relevant for the students in a common "Student's Handbook", the common definition of learning outcomes, the establishment of shared teaching and examination methodology, the common approach for internship supervision (with a tutor from the academy, a tutor from the institution/industry, and a fully joint examination committee), the joint evaluation of Internships defences, the introduction of cultural

activities, the implementation of common quality control mechanisms, and the development of a joint and integrated management structure, among others. The
consortium has already put in place a system to exchange academic and administrative information accessible by all the members to facilitate the management of the master course.

A joint application and selection procedure is also organized in collaboration between the NucPhys Secretariat and the Selection Committee composed by one member of each partner organizations and two associated partners, as well as a joint recognition mechanism of grades and credits. Students are also involved through the participation of their representatives in the Academic Committee meetings and implementation of monitoring and Quality Assurance activities.

Mobility plans are being carried out among administrative staff and lecturers among the universities of the consortium.

The shared knowledge and consistent student services between Universities. These include the organization, at the local level, of services and networking activities to incoming students. Local administrative staff at the International Offices of each partner universities works jointly (including mobility training periods) on all administrative and financial issues and exchanging students' documents for the monitoring of their academic performance in connection with the Academic Local Coordinator at each partner university.

Regular meetings to monitor and follow up the implementation of the project. At least once per year, all the consortium members (including academic and administrative coordinators) meet to discuss about the results obtained. In addition, as novelty in this proposal, a second meeting will be organized with the academic coordinators at the beginning of the academic course to define the calendar and the activities to be organized. Online meetings are also organized periodically to ensure a continuous monitoring.

A joint evaluation of the internship. The evaluation of the internship (12 ECTS) is fully common, with a public defense and a jury composed of the academic representative of the Consortium universities.

A joint end of course ceremony in which all successful students will receive their diplomas will be organized in one of the partner universities on a rotational basis.

Joint academic governance structure and joint administration and financial management.

Joint transparency and documentation procedures. With the support of NucPhys Secretariat, NucPhys will be jointly promoted, ensuring the visibility of the joint programme, and providing information to students and other stakeholders such as future employers.

And finally, a **Joint internal quality assurance system**.

Basic Information

Name of the programme: Joint European Master Degree in Nuclear Physics

EQF level: 7
QF-EHEA level: 2nd cycle

Degree awarded: Joint European Master Degree in Nuclear Physics

Number of ECTS points: 120

ISCED field(s) of study:

1. Eligibility

1.1. Status

The General Roadmap for the accreditation and awarding of the joint degree

The six consortium partners are well-established Higher Education Institutions in their respective countries (**Annex 1**). They all have applicable legal national frameworks, which entitle them to participate in a joint programme (**Annex 3**). However, only France and Spain can implement the use of the European Approach for Quality Assurance of Joint Programmes.

Table 3, summarizes the status of the national and regional evaluation agencies regarding their inclusion in the EQAR register, the acceptance of the European Approach for Quality Assurance of Joint Programs, the cross-border quality assurance, and the awarding of joint degrees, in the six NucPhys partner Universities and countries.

Table 3. Status of the external quality assurance systems, as well as national frameworks for joint programmes, in NucPhys countries and Universities.

University/ Country	Evaluation Agency registered in EQAR	Accepts the EA for accreditation of joint programmes	Accepts cross-border quality assurance	Awarding a joint degree
USE, UCM, UB / Spain	Yes	Yes	Yes	Yes
UniCaen / France[1]	Yes	Yes (under conditions)	Yes	Yes
UniPD, UniCT / Italy	No	No	No	YES (under new Interateneo accreditation request, see text)

According to Table 3 and the above text, this proposal involves a joint master degree designed and participated by the six NucPhys partner universities, but that, due to regulatory constraints, will be accredited and awarded in a first step by the Universities sited in Spain (USE, UCM, UB) and France (UniCaen).

With the firm purpose of awarding a full joint degree between all NucPhys partners' HEIs, in a second step the Italian Institutions (UniPd and UniCt) will proceed possibly with the European Approach for Quality Assurance or, if not yet available for Italian HEIs, they commit to proceed with their National Accreditation procedure allowing the delivery of a Joint Degree, I.e. Interateneo accreditation procedure.

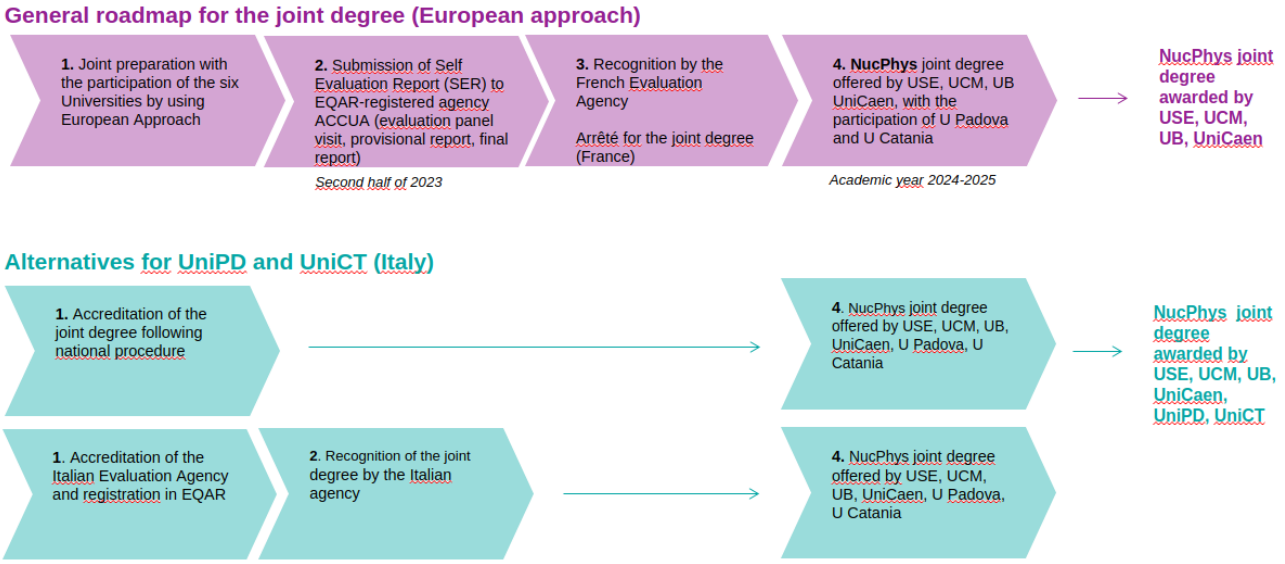
It should be noted that the Italian Evaluation Agency (Anvur) is not currently registered in EQAR, but it is in the process of accreditation for registration. If this happens, and the Italian law is

[1] In France, for the recognition of reviews carried out by foreign agencies, HCERES checks the external quality assurance activity, whether it corresponds to the national qualification framework and whether the foreign quality assurance has effectively involved students in the review. The European Approach could be used subject to the general conditions for recognizing QA results of EQAR-registered agencies.

changed to accept the European Approach and cross-border quality assurance, the joint programme accredited by the Andalusian Evaluation Agency DEVA could be recognized by the Italian Agency.

Upon accreditation in Italy, NucPhys will be jointly offered and awarded by all six Universities. **Figure 2** illustrates the step-by-step approach for the accreditation and awarding NucPhys. The upper part of the scheme concerns the accreditation process involving the current proposal.

Figure 2. Step by step approach for accreditation and awarding NucPhys in France, Spain, and Italy.



1.2. Joint design, delivery, and implementation

Distribution of roles among Partner universities, students, and associated partners in NucPhys

NucPhys follows an integrated approach involving the participation of partner universities, students, and associated partners, and distribution of roles among them. This is illustrated in **Figure 4** and explained in more detail in the following text and sections.

- The six partner universities are coordinated by the USE.
  - USE is responsible for coordinating the accreditation of the joint programme, participated by the six partner universities. Due to regulatory constrains (see above), the joint programme will be only accredited in Spain (through DEVA) and France (upon recognition by the EQAR-registered French Evaluation Agencies).
  - Given that, at the moment, Italy is not part of EQAR register and thus cannot participate in the European Approach accreditation, two different degrees will be awarded to students participating in the programme. USE, UCM, UB, and UniCaen will award a joint degree, following the joint accreditation through the European Approach. Italian partners, i.e. UniPD and UniCT, will for the moment award an Italian National Degree, in addition to the joint degree, to the students that spend a semester (or longer) at UniPD or at UniCT respectively (students will visit one or the other according to the path chosen, see **Annex 5 and 6**). In the medium-long term, it is expected that Italian universities can join the European Approach and thus also award a joint degree. Despite the difference in degree awarding, all partners - including the Italian ones - are fully part of the Master Programme and will enrol students as degree-students at their university.
  - As coordinator, USE is also appointed for issuing of the physical joint degree (diploma), and its joint diploma supplement, awarded by USE, UCM, UB, and UniCaen. USE will be also in charge of the administrative and financial management of NucPhys through the master Secretariat that will be sited at the USE International Graduate School.
  - All the six partner universities jointly participate in the joint academic governance, admission and recognition, teaching and evaluation, master thesis supervision and assessment, mobility, traineeships (research), and internal QA procedures. They all provide students support, resources and promotion and dissemination of the joint programme.

- NucPhys students have participated in the joint programme evolution and will participate in NucPhys academic governance and internal QA procedures. They could also participate in peer-teaching and assessment, on a voluntary basis.

- NucPhys associated partners have a decisive role in the design and implementation of the joint programme. NucPhys has so far more than 30 associated partners comprising enterprises, research centres and an interuniversitary PhD programme distributed among Europe, Africa and America. All of them have committed to collaborating in NucPhys activities (see additional **Annex 15** for a list and a selection of commitments letters from associated partner). Among then, a reduced group contributed to the design and evolution of the joint programme (see additional **Annex 16**).

- NucPhys associated partners will participate in the academic governance and QA structure, admission and selection of students, teaching & training (with an important role in promoting innovation and entrepreneurship), and supervision and evaluation of the master thesis. They will provide places for professional traineeships, and student's support.

Figure 4. Distribution of roles of partner universities, students, and associated partners in NucPhys.

Partner universities	Roles	
USE	General Coordination Administration & financial management Accreditation (EA) Enrollment Awarding the joint degree and joint DS	Programme design Governance Admission, Selection, Recognition Teaching & Training Assessment Master Thesis supervision Mobility Internships (research) Students' support Resources Promotion and dissemination Internal Quality Assurance
UCM, UB, UniCaen	Enrollment Awarding the joint degree and joint DS	
UniPd, UniCT	Enrollment in own Italian National Degree Awarding Italian National Degree and DS	
Students	Programme design Governance Peer-teaching & Assessment Internal Quality Assurance	
Associated partners	Programme design Governance Admission, Selection Teaching & Training Assessment Master Thesis supervision Mobility Internships (professional) Students' support (i.e., career guidance) Internal Quality Assurance	

Joint design of NucPhys

This programme has been jointly designed by the 6 NucPhys partner universities, their students, and their associated partners, under the coordination of the University of Seville. The programme here proposed is the evolution of the Erasmus Mundus Master in Nuclear Physics that started on the academic course 2017/2018 and that has been funded twice by the EACEA as Erasmus Mundus under grant agreements 2016-2070 and 2019-2130. We would like to acknowledge also here the contribution to the design and evolution of the programme of two Spanish HEI's, Universidad de Salamanca and Universidad Autónoma de Madrid, that were part previously of NucPhys consortium.

The mobility of students and the programme have been designed to exploit the best expertise of all six members of the consortium and some of our associated centers (see **Annexes 5 and 6**). In this regard, the major change in the mobility scheme was made between the first and second Erasmus Mundus Project, consisting of designing a common first semester to all students, regardless of the specialization path chosen, at the coordinating HEI with a welcomed ceremony jointly performed by all partners. This change was also promoted by previous students and the Academic Committee (where students are also represented, see Joint structure section) with the aim of strengthening cohesion and teamwork amount the full intake of students. This has helped the internal organization of students overcome both academic and external issues (visa,

language, cultural challenges) and has also contributed to a more effective representation of students in the different committees of NucPhys.

This new first semester is also intended to bring all students to an initial even level of knowledge. This S1 semester will be lectured in Seville as coordinating institution. This will allow doing all administrative tasks relative to inscriptions, visas, etc., in a centralized way from the beginning. Then in S2 starts the specialization: path 1 in Padova taking advantage of LNL and the academics and facilities related to large accelerators, path 2 in Spain using the strong theory groups in Madrid, Barcelona and Seville, and path 3 in Catania taking advantage of LNS and the AOUP (Azienda Ospedaliero-Universitaria Policlinico di Catania) with academics and facilities related to many Nuclear Physics applications. In S3 all students move to Caen, in which there are large scale nuclear physics facilities like GANIL, but also an important theory group and many industries/laboratories around that are associated members of this Master and guarantee the appropriate internships in S3.

Since the beginning, all consortium members were interested in a future delivery of a joint degree in Nuclear Physics. Along these years, we have become more acquainted with the process and some HEI's have accredited recently some Joint master's degrees through EQAR. The Academic Committee decided in January 2023 to finally start the process. After several contacts between local organizers and HEI's representatives the decision to develop the proposal for the joint master degree following the European Approach for Quality Assurance of Joint Programs was taken. For this purpose, a taskforce was set up in June 2023 to design the proposal and the study programme, divided into two groups:

a. The European Approach Group, in charge of developing all administrative parts of the SER and coordinating the drafting and submission of the proposal. The "Guide for the evaluation of international joint programmes within the European Approach framework for quality assurance", established by the Andalusian Evaluation Agency DEVA, was followed. This group was formed by representatives of each of the six universities with responsibilities in Academic and Student Affairs, Internationalization, and external and internal Quality Assurance.

b. The co-creation Group, in charge of the academic content of the SER: learning outcomes, study programme, and student's assessment. This group was in turn composed of 3 subgroups:

- Present local coordinators and experts coming from the 6 NucPhys universities.
- Former and present students. A selection of students and their representatives have been contacted about program learning outcomes, as did in the past. Indeed, also in 2019 the programme has been redesigned according to students' suggestions till reaching the present structure of the programme.
- A selection of Nucphys associated partners, representatives from public institutions (see additional **Annex 16).** They ensure that the program is adapted to the needs of different employers, and that we grasp the need for specific skills and knowledge to educate and train fully employable students for their future professional careers.

Joint structure for academic governance, internal quality assurance, administration, and financial management

Financial tasks will be mainly managed by the University of Seville as coordinating institution. For the rest of the tasks, four committees have been created in order to resolve the different issues

related to NucPhys (see **Figure 4**). Every full partner takes part in these committees and there is representation of the associated partners. The committees are:

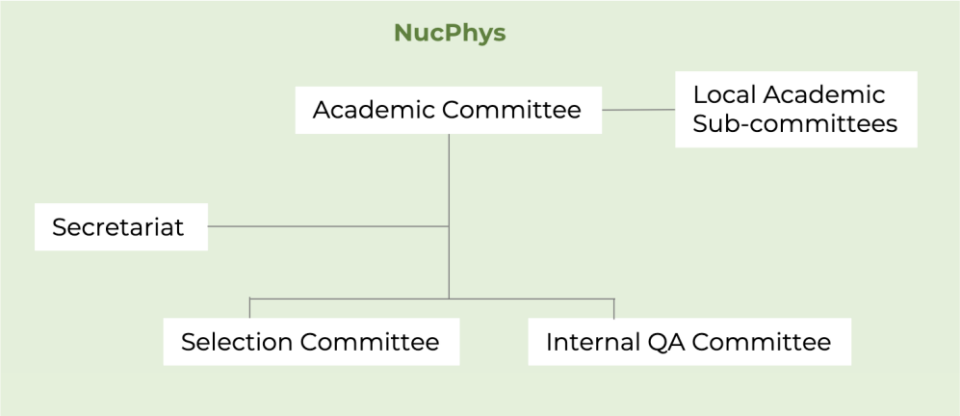
- **Academic Committee:** it is responsible for the correct implementation of NucPhys and the general management. It will be formed by one local academic of each full partner (universities), two representatives of the associated members and one student. In addition, it is in charge of examination methods and the organisation of the Master Thesis work. It is also responsible for the contents of NucPhys. This committee will have 3 sub-committees (one at each country). Each sub-committee will be presided by the academic that is part of the Academic committee plus two academics that belong to their own universities. The aim of the sub-committees will be to solve all the academic issues within their own university. The Academic Committee will also oversee obtaining the necessary number of internships for the training period in a company for all the students participating in NucPhys. The academic committee will also be responsible for the final assignment of the internships among all the students according to their preferences and the advice of the local coordinator in contact with students. Another important aim of this committee is to develop a joint and well structured curriculum for NucPhys that takes into account the best expertise of every full partner and the present needs of companies related to Nuclear Physics.
- **Selection Committee:** it is in charge of the issues related to the admission criteria, and selection procedure. It will be formed by one academic from each full partner (universities) as well as one person representing the associated partners. This committee will have regular meetings (mainly on-line) before the beginning of each NucPhys edition to manage all applications received and to apply the admission criteria for the student selection process.
- **Quality committee:** it is needed to ensure the internal NucPhys quality and to design improvement strategies. This committee is formed by one academic of each full partner (universities), two representatives of the associated partners, and two students of the present NucPhys edition. This committee will implement all the internal evaluation strategies and mechanisms. It will also be in charge of coordinating with the external organisms/institutions/agencies responsible for the external quality assurance of NucPhys.
- **NucPhys Secretariat:** it is the executive board, in charge of executive management, communication with EACEA, administrative and financial management. It is located at the coordinating institution and is composed by the Consortium coordinator, one project manager, one administrative assistant and supported by the International Office at USE. It is in contact with local administrative staff at partner institutions and supervises exchange of student documents among partners. The Secretariat ensures update of the website and application system. It should be mentioned, that in order to have a continuous coordination within the committees, most of the meetings will be held by means of electronic communication systems and internet. Nevertheless, the Academic Committee will have at least two meeting per year. The first one will be at the beginning of the year with the occasion of the welcome ceremony. The other one will coincide with the internship defenses that will be done jointly, with an internship defense committee composed by representatives of the different consortium members. Further meetings if needed, will be held in any of the 3 countries.

The committees make the proposals for improving the Master Programme and management of the Master and the Universities in the consortium are the responsible for the specific implementation. From the academic point of view, Seville University is responsible for the organization of S1 (see **Annexes 4 and 5**), the University of Padua is responsible for the implementation of S2 in path 1, the Spanish Universities are responsible for S2 in path 2 and University of Catania is responsible for the implementation of courses in S2 for path 3. University of Caen is the responsible for the

academic organization of S3, this includes the organization of the common specialized course and the design and assignment of the internships in S3. The Academic Committee is responsible of offering Master Thesis topics appropriate in number and matters for all students in an intake. For this task, the proposals from all members in the consortium and associated centres are crucial.

All partners undertake to develop all promotion and marketing measures. The consortium abides by the terms and principles of the proposal for a European Quality Charter for Mobility, following its recommendations to provide the best service as Host Institutions.

Figure 4. NucPhys joint structure for academic governance, administration, and financial management.



Students involvement in NucPhys coordination:

Students will be involved in the course coordination and implementation tasks as part of the feedback obtained from the evaluation questionnaires administered to students to evaluate the different modules. In this way a constant improvement of NucPhys is obtained. A delegate and a deputy will be elected among students for every intake to represent them in daily issues. The delegate will be part of the Master Academic Committee and the deputy will take part in the Quality Committee. As two intakes coincides on each academic course, two students will be included in the Academic Committee and another two in the Quality Committee.

1.3. Cooperation Agreement

A Cooperation Agreement for NucPhys is attached to this SER (**Annex 2**).

2. Learning outcomes

2.1 Level

NucPhys uses Learning Outcomes (LOs) that describe what a student knows, understands, and is able to do upon completion of the programme, and workload (ECTS) in its curriculum design and delivery in placing the student at the centre of the educational process.

NucPhys graduates are expected to have achieved at graduation all the five LOs defined by the level 7 of the QF-EHEA[3], corresponding to the second cycle.

The main outcome at the end of the NucPhys programme is that participants will have advanced knowledge with a first research/working experience in the Nuclear Physics field. This will directly enable them to successfully perform doctoral studies or to be inserted in research/working teams in Scientific Centers/Companies/Industries/Medical Centers/etc.

The learning outcomes at the end of the NucPhys Master, defined according to the Dublin Descriptors, are as follows:

- About knowledge and understanding, the participants should be able to:
  - PLO1: describe, analyze and comparatively assess the most important parts in Nuclear Physics, their rationale and participation procedures, as best practices and as guidelines for future development and improvement of Nuclear Physics strategies
  - PLO2: take part in an experiment in top experimental facilities using current techniques and new developments. It includes: understanding the basic setups, systems of data acquisition, basic electronic chains, main particle and radiation detectors, and the corresponding data analysis, knowledge of particle accelerator techniques, and safety measurements
- About applying knowledge and understanding, the participants should be able to:
  - PLO3: describe and evaluate Nuclear Physics state-of-the-Art
  - PLO4: understand technical specificities and relevant strengths of main current facilities, projects, and experiments in Nuclear Physics worldwide.
  - PLO5: knowledge of main programming languages, numerical techniques, data management, software tools and methods currently used in Nuclear Physics theory and experiments.
  - PLO6: apply knowledge, understanding and problem-solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their master degree's field of study
  - PLO7: participate in a team to apply knowledge and to develop new possible Nuclear Physics applications.
- About making judgements, the participants should be able to:
  - PLO8: evaluate critically issues and discussions on Nuclear Physics
  - PLO9: set and apply integrated and pluralistic evaluation methods in a specific Nuclear Physics context
  - PLO10: identify most suitable planning tools for a particular problem either theoretical, experimental or applied.
- About communication skills, the participants should be able to:
  - PL11: use a standard format of writing professional reports
  - PLO12: know the basic principles of writing a scientific publication

- PLO13: sustain an English scientific conversation on Nuclear Physics. They will have a high-level fluency and knowledge in technical English, in particular that associated with the Nuclear Physics field
- PLO14: organize and participate in a teamwork, while specifying his/her specific role in the team
- PLO15: communicate their conclusions (knowledge and rationale behind) to specialist and non-specialist audiences clearly and unambiguously, as they would do in their professional life in Nuclear Physics
- PLO16: communicate in as many national languages (Spanish, French, Italian) as they desire
- PLO17: give short oral presentations in the field of nuclear physics in front of a specialized audience
- PLO18: prepare scientific communication material.

- About learning skills:
  - PLO19: plan, design and manage information systems (data analysis and processing), with respect to specific decision support systems in Nuclear Physics
  - PLO20: identify and describe suitable systems, technologies and tools to measure and monitor new Nuclear Physics advances
  - PLO21: enrich personal experience by living in different European countries, immersion in their culture, and working with classmates from different countries all over the world
  - PLO22: know the basic principles of preparing a proposal.
  - PLO23: know the basic principles of the Intellectual Property Rights
  - PLO24: know the basic principles of the entrepreneurship

With reference to the relevance of the aforementioned learning outcomes in view of the students´ future academic opportunities and employability it is important to highlight that Nuclear Physics constitutes a field of knowledge closely connected both to present research and to top industry.

The alignment of the NucPhys PLOs with the QF-EHEA and EIT learning outcomes is included in **Annex 4**. All these PLOs will be transformed into more specific Module Learning Outcomes (MLOs) in order to equip the students with the desired skills and competences (see **Annexes 5** & **6**).

2.2. Disciplinary field

Nuclear Physics is a broad matter of relevance from both the fundamental knowledge of Nature and the multiple applications to different fields of strategic economical relevance. These include energy resources (based on fusion or fission), biomedical sciences, analysis and characterization of new materials, environmental studies (atmosphere, soil, waters), dating, art and archaeometry, airport and toll security, military applications, industrial automatization and control, fire surveillance, among others. There is a clear need to support the development of nuclear competences at the European level. **However, there was no international teaching programme in Europe at the Master level devoted specifically to Nuclear Physics before NucPhys**.

The present project was born with the intention to educate Nuclear Physicists at the highest international level. Such a highly specialized curriculum, by definition, can only be addressed to a very restricted number of students in few universities. For this reason, most European University centers include Nuclear Physics only as a specialization embedded in a larger and more generic curriculum including other branches of Physics. Thus, only relatively generic and interdisciplinary Master Courses called "Physics", "Science", "Nuclei, Atoms and Collisions", "Particles and Nuclear Physics" or "Advanced Physics" are found in most European Universities. **This situation had clearly a detrimental effect on the visibility of Nuclear Physics as a well-defined branch of Physics with important theoretical, experimental and applied implications**. An exception was the case of Spain, where the University of Seville coordinates a specific joint Master Degree on Nuclear Physics, with the participation of other five Universities (Autónoma de Madrid, Barcelona, Complutense de Madrid, Granada, and Salamanca). This Master Course has been running during the last eight years with excellent results.

With this experience, **we created a new and stronger international consortium by adding University of Padova, University of Catania and University of Caen-Normandie**, who brought high-experienced researchers and top-level nuclear physics facilities. With these partners, **we now offer a complete programme including theory, experiments and applications, covering all different aspects of the nuclear field**. Hence, the consortium offers a highly specialized curriculum in the form of a joint European Master Course on Nuclear Physics (NucPhys).

This consortium is strengthened with the participation, as associated partners (see Annex 14), of most of the large facilities for nuclear physics worldwide, as well as hospitals and companies. Initially, these associated centers were located in Europe. Once the consortium has been consolidated, it is being expanded with the addition of new international partners from all the continents to be able to reach any interested student in nuclear physics all around the world. In the last two years, the network of associated partners has been expanded through the addition of new collaborations with institutions from America, Asia and Africa.

The present 120 ECTS international joint study programme, "European Master in Nuclear Physics" (NucPhys) aims to educate experts in the field of Nuclear Physics, in order to meet the needs and challenges previously cited. It has a double educational approach. First, to train well-prepared specialists to be incorporated directly into the industry in any of the fields mentioned above. Second, to train students able to develop research programmes and make their PhD in the field of Nuclear Physics: theoretical, experimental or applied. This will be accomplished by gathering the strong research expertise of Universities from 3 European countries (Spain, France, and Italy), and the collaboration of the most important European and worldwide nuclear research facilities (institutional or industrial) that participate in the project as associated partners. This double approach is a key factor for the development of the necessary European competences in this fundamental field.

Students of NucPhys are trained in nuclear technology, safety and radiation protection. The proposal addresses the integration of students in the industry and other institutions (i.e. hospitals), and seeks to bring young researchers into Euratom-supported research projects. The aim is to respond to the needs of the nuclear industry and the corresponding regulatory bodies. Also important are the so-called nuclear activities of proximity, which include medical applications, the relevant non-nuclear industrial applications and the transport of radioactive materials. In line with the strategy for EU international cooperation in research and innovation (COM(2012)497), international cooperation is fundamental and is the basis of this programme.
The creation of the Nucphys consortium specially designed to integrate the best expertise (needed to create an assembled, well-based and complete programme) was a necessary step forward to achieve these objectives, because none of the mentioned institutes could alone offer a complete study career that covers all aspects of this multi-faceted field.

It is important to note that we propose three specialization paths (see **Annex 5 and 6**) so as to cover all branches of Nuclear Physics. In path 1, (experiments and instrumentation in large accelerators) students are in contact with forefront nuclear physics experiments and with the companies working in the field (electronics, vacuum, electromagnetism, new materials, etc.). In path 2 (theoretical), students will learn more academic topics related to fundamental interactions and components of matter. In path 3 (applications and small accelerators), students will learn about many applications of nuclear physics, in particular: material analysis, therapy (including the new hadrontherapy), archaeometry, medical imaging,etc. They will be also in contact with companies developing instrumentation for applications. These three lines cover both, academic and professional important aspects for the future of the nuclear physics young generations.

2.3. Achievement

To achieve the programme objectives, the joint degree profile (above) has been developed and agreed upon by all partners in a co-creation effort. This includes Programme Learning Outcomes (PLOs) that describe what the student knows, understands and is able to do upon completion of the programme, but also aspects related to the study programme, learning, teaching and assessment. Students, sector professionals and academic experts have contributed to this process, guaranteeing that all perspectives are considered by the programme, with especial regard to the intended learning outcomes, innovation in the learning process and evaluation of competence acquisition.

To achieve the learning outcomes, NucPhys proposal is a 120 ECTS Master Course of 24 months' duration. The Master is structured for all studets in 5 modules and divided into 4 terms (semesters). A common basis of fundamental knowledge is given to all students during the first semester. A progressive specialization is then acquired through the choice of one out of three different paths.

The curriculum has been designed coordinately by all members in the consortium taking into account the expertise of the different nodes. Also, the previous experience has convinced the consortium of the convenience of having a common first semester (S1) with general matters so as to bring all students to an initial even level of knowledge. This S1 semester will be lectured in Seville as coordinating institution. This will allow doing all administrative tasks relative to inscriptions, visas, etc., in a centralized way from the beginning. The fact that the entrance university is the same for all students, and therefore the basic courses are common to all insures a completely even background and further increases the links among students of a given intake.
Then in S2 starts the specialization: path 1 in Padova taking advantage of LNL and the academics and facilities related to large accelerators, path 2 in Spain using the strong theory groups in

Madrid, Barcelona and Seville, and path 3 in Catania taking advantage of LNS and the AOUP (Azienda Ospedaliero-Universitaria Policlinico di Catania) with academics and facilities related to many Nuclear Physics applications. In S3 all students move to Caen, in which there are large scale nuclear physics facilities, GANIL, but also an important theory group and many industries/laboratories around that are associated members of this Master and guarantee the appropriate internships in S3. Finally, the topics of the internships (S3) and Master Thesis (S4) will help the student increase its specialization in the chosen path.

All the details concerning the study programme, student's support, and how to participate in NucPhys will be provided in the "NucPhys Student Handbook" (additional **Annex 19**).

Details about how learning outcomes are targeted and progressively built upon each other, are to be provided in the Student's Handbook as well**.** Within the Student's Handbook**,** each module (and course) will have a guidebook describing the context within NucPhys programme and overall objectives. According to the Bologna strategy and the TUNING methodology, the guidebooks will also include the workload, intended learning outcomes, the courses' contents, the teaching and learning methodology, assessment criteria and assessment methods, and any other necessary information (see **Annex 5** and **Sections 5 and 6**). This information will be made available to students before they start their modules.

2.4. Regulated Professions

The European Union Directive 2005/36/EC establishes rules for recognition of regulated professions among EU Member States. NucPhys programme does not align to a regulated profession, it is important to highlight that Nuclear Physics constitutes a field of knowledge closely connected both to present research and to top industry.

Internship will be also an occasion to acquire academic and complementary skills. Participant Universities have provided a list of laboratories and external companies (that may be enlarged in the future), in which students could perform their internship. NucPhys will offer students a choice between a professional and a research internship and will provide strong guidance through the joint supervision of two tutors, one from the company/host institution and another from the home University. This will equip students with professional skills and enhance student employability. The possibility of doing a Master thesis in collaboration with associated centers will also be promoted, following the same scheme of joint supervision of two tutors.

In addition, the Academic Commission will help students interested in performing summer internships with the help of our associated centers. In the past, the consortium has also enlarged the network of associated centers following the interest of our students. Associated centers will also have the opportunity to connect with our students through organized seminars, visits, and career guidance activities.

Finally, it is important to remark that an essential part of Nuclear Physics is devoted to research and innovation, theoretical, experimental or applied. As a result, a non-negligible part of our students decides to pursue a PhD in Nuclear Physics after the completion of the Master.

3. Joint Study Programme

3.1. Curriculum

General overview of the programme structure and content

Students of **NucPhys** are trained in nuclear technology, safety and radiation protection. The proposal addresses the integration of students in the industry and other institutions (i.e. hospitals), and seeks to bring young researchers into Euratom-supported research projects. The aim is to respond to the needs of the nuclear industry and the corresponding regulatory bodies. Also important are the so-called nuclear activities of proximity, which include medical applications, the relevant non-nuclear industrial applications and the transport of radioactive materials. In line with the strategy for EU international cooperation in research and innovation (COM(2012)497), international cooperation is fundamental and is the base of this proposal.

The creation of the Nucphys consortium is specially designed to integrate the best expertise (needed to create an assembled, well-based and complete programme) was a necessary step forward to achieve these objectives, because none of the mentioned institutes could alone offer a complete study career that covers all aspects of this multi-faceted field. A renewal of this programme which is further improved in this submission will be essential to continue to attract excellent non-European students in the field of Nuclear Physics.

It is important to note that we propose three specialization paths (see below for details) so as to cover all branches of Nuclear Physics. In path 1, (**experiments and instrumentation in large accelerators**) students are in contact with forefront nuclear physics experiments and with the companies working in the field (electronics, vacuum, electromagnetism, new materials, etc.). In path 2 (**theoretica**l), students will learn more academic topics related to fundamental interactions and components of matter. In path 3 (**applications and small accelerators**), students will learn about many applications of nuclear physics, in particular: material analysis, therapy (including the new hadrontherapy), dosimetry, radiation protection, archaeometry, medical imaging, etc. They will be also in contact with companies developing instrumentation for applications. These three lines cover both academic and professional important aspects for the future of nuclear physics' young generations.

DESIGN AND STRUCTURE OF THE PROJECT

The design and structure of the project has been done by all partners in the consortium in order to produce a top-level master's degree from the academic point of view and to favor the networking among both institutions and students from the beginning.

Our proposal is a 120 ECTS Master Course of 24 months' duration. The Master is structured for all students in 5 modules and divided into 4 terms (semesters). A common basis of fundamental knowledge is given to all students during the first semester. A progressive specialization is then acquired through the choice of one out of three different paths. The academic content of the different courses and the progressiveness of the specialization are further optimized by this

renewed proposal, by the fact that the entrance university is now the same for all students, and therefore the basic courses are now common to all. This ensures a completely even background and further increases the links among students of a given intake. Moreover, a new course on advanced computing has been included, thus insuring to all students the compulsory background for a successful completion of their internship in S3 and employability after graduation.

The NucPhys Master program will start with an **orientation week** in the entrance university, Seville. During this week a **welcome ceremony** will be organised that will gather together new students, professors from all the consortium partners, alumni and some representatives from associated partners. Besides coordinators of each Consortium university will welcome students and introduce the NucPhys program, **associated partners and alumni will be invited to give a presentation of their current professional situation** to motivate our students about their career opportunities once the master is ended and to have a better idea of how the nuclear physics sector is working. Some alumni will be invited to become in person and some other will participate online telling their experience to the new students. This first step of networking among students provides the opportunity to exchange views, experiences, and plans with each other at a very early stage.

Initial knowledge of students will be checked during the orientation week through a “Pilot Test” and online dedicated resources will be available for bridging possible gaps in order to assure the same starting point to all students. Our students arrive from very different academic environments focused on different backgrounds and skills, thus generating serious difficulties to foreign students both on tackling the different contents but also with understanding the evaluation system of each University. This has been our main risk and source of failure among the students. In this new edition we expect to overcome this issue by establishing a network of tutorships. Those students finding difficulties will be assigned a tutor (second-year students of the master or professors). Potential tutors will be encouraged to enroll and to have periodic discussions with students on which skills are expected to be evaluated and how, evaluation systems, bureaucratic procedures, etc. With this we expect to help especially foreign students to overcome the initial disadvantage of starting a programme in a different academic environment.

The Master is structured in 4 semesters and three different paths or specializations. Beside the common first semester, all students also follow a common course on advanced data analysis and machine learning techniques, tools that are of paramount importance for all nuclear physicists. The specialization in the different sub-disciplines of nuclear physics is obtained through the specialized courses of S2 and S3, the part-time internship in a research lab, and in the Master thesis work in one of the universities of our consortium or associated centers during S4.

Below the characteristics of each path are briefly explained:

PATH 1 – EXPERIMENTAL AND LARGE ACCELERATORS

The aim of this path is the advanced education in experimental Nuclear Physics using large

accelerators. Most of the largest accelerators in the world are associated partners of this Master and students could have the opportunity of visiting these facilities.

The path includes master-level courses in Quantum Mechanics, Structure and Reactions in Nuclear Physics, Experimental Techniques such as the ion beams production and the different detection systems at basic and advanced level, and different applications of Nuclear Physics, etc. Additional extra-curriculum courses will be offered as computing and numerical calculations, plasma physics and fusion with the participation of external experts.

Thanks to high-level education on general aspects in subatomic physics and to specific experimental and technical acquired competences, students can be projected towards different career opportunities both in the academic sector (fundamental research in physics) and in the R&D department of industries in all the technology sectors dealing with ion beams, data acquisition and instrumentation. A continuation in PhD is also foreseen.

PATH 2 - THEORETICAL NUCLEAR PHYSICS

The specific objectives of the theoretical path can be identified with providing the students with a solid preparation in several features of nuclear structure, nuclear dynamics, nuclear astrophysics and in various other aspects of theory of fundamental interactions.

The students will have the opportunity to interact with major experts in the various fields at the international level. Besides this, this path aims at the training on the use of particle detectors, and of other experimental instrumentation for the study of Physics of Fundamental Interactions, Matter and Astrophysics. The students will also learn recent technics for data taking and analysis.

The theoretical path has as natural development an academic career and/or an activity in research in fundamental nuclear and particle physics and astrophysics. Furthermore, the skills acquired, and the high level of scientific preparation will be able to provide these students with job opportunities in all the different fields needing modelling, data storage and analysis, software package development and related areas. A continuation in PhD is foreseen.

PATH 3 - APPLICATIONS AND SMALL ACCELERATORS

The aim of this path is the advanced education of young students to different applications (medicine, environment, archaeometry, accelerators, etc.) in the field of Nuclear Physics.

The path includes master-level courses in Quantum Mechanics, Statistical Mechanics, Nuclear Physics and Nuclear Astrophysics. Furthermore, advanced courses in nuclear physics applications will be held also with the participation of external experts. Both in the regular courses and in extra activities, students will be approached to experimental techniques, detectors, accelerators and analysis procedures. Different activities are programmed, including a visit to the Laboratory Nazionali del Sud, including the two accelerators, the experimental halls and the Radioactivity Laboratory.

The high-level education on general aspects in subatomic physics and the specific experimental and technical competences acquired in this path concerning the different nuclear physics applications of social interest will allow students to access executive positions in companies or

laboratories dealing with radiation protection, waste management, proton and hadrontherapy, radioisotopes for medicine, archaeometry, accelerators, etc. A continuation in PhD is also possible.

The general scheme ECTs distribution of the Course is presented in **Table 4**, giving the number of credits associated to each module (see below) according to the mobility and specialization path:

PATH 1 - EXP: Large accelerators (~1/3 of the students)

PATH 2 - THEO: Theoretical Nuclear Physics (~1/3 of the students)

PATH 3 - APP: Small accelerators (~1/3 of the students)

Table 4. ECTS distribution on the different paths and modules.

	MOD1	MOD2			MOD3	MOD4	MOD5
		EXP	THEO	APP			
PATH 1	30	24	12	6	6	12	30
PATH 2	30	0	42	0	6	12	30
PATH 3	30	6	12	24	6	12	30
Total	30	42			6	12	30

Concerning contents, the academic programme is structured in 5 modules:

Module 1: Basics nuclear physics and tools (30 ECTs in S1)

Module 1 (BAS) will be devoted to the basic knowledge required on general Physics, and Complementary/Interdisciplinary courses adapted to the chosen path (notably numerical methods and computing). These courses will be concentrated in the first year, in S1, and include topics as Quantum Mechanics, Basic Nuclear Physics: theory and laboratory, Computing and Numerical Methods, and Atomic and Plasma Physics

Module 2: Advanced nuclear physics (42 ECTs in S2 and S3), with three specialties (experimental, theory, applications)

Module 2 allows students to follow 3 paths: Experimental/large accelerators (path 1), Theoretical (path 2), or Applied/small accelerators (path 3). This module will give the specialized focus of the Master curriculum towards fundamental or applied nuclear physics. Fundamental physics

includes either an experimental or a theoretical focus. Applied physics is especially focused on biomedical applications, but also includes fundamentals in accelerators technology, archaeometry, monitoring of nuclear waste, and nuclear fusion plasma physics. The specialization is progressive, starting already in the first year (S2), then continuing in S3 with courses and specific internships, to finalize in S4 with the master thesis. Academic topics in S2 and S3 include Nuclear Structure and Reactions, Nuclear Astrophysics, Weak and Strong Interactions, Collision Physics, Many Body Theory, Nuclear Physics Applications: Art, Materials, Radiation protection, radiotherapy and the physics of medical devices, Metrology and Data Analysis, Experimental Nuclear Physics, Advanced Nuclear and Subnuclear Laboratory, and Accelerator Physics and Advanced Instrumentation.

Module 3: Common advanced course (S3 course, 6 ECTs)

Module 3 (ADV) is devoted to a highly specialized topic that will be selected for each intake among the hot topics in Nuclear Physics. During two weeks at the end of S3 this special topic will be presented by invited scholars in Caen, France. The choice of period and location is done to optimize the mobility scheme of the students (see below). At present, we have decided to continue the previous programme on “Data Analysis and Machine Learning”, in principle provided by Prof. Morten Hjorst-Jensen from the University of Oslo (Norway) and Michigan State University (USA).

Module 4: Internship (12 ECTs)

Module 4 (INTERNSHIP) will be done in the third semester (S3). It is dedicated to student internship (experimental, theoretical or applied topics are accepted), which will take place in different institutional or industrial research centers in Caen (France) according to the chosen path and desired specialization. Students will work in teams of two, will be supported by internal (Consortium) and external (Associated Members) tutoring and will be fully integrated in the research centers within appropriate signed agreements during the whole semester (from September to December), where they will perform their internship project part-time. The internships are programmed by the University in advance, so as to provide a real working experience, valuable for future job placement. A “Practice Oriented Day” is organized at the beginning of the third term in Caen, so as to present the Internships programs, to share the discussion on the work topics, aims and methods with students, and to consolidate the Consortium network. The evaluation of this module is fully common, with a public defense and a jury composed of the academic representative of the Consortium universities. This common evaluation is an extra jointness feature of our programme. First year students are also invited to the defense, and we take the opportunity of the event to organize extra-curriculum team-building activities in Caen for the students of the two concerned intakes. This exposes the younger students to practical examples of the professional activities that they can undertake for their practice-oriented formation, and moreover facilitates the creation of a real NucPhys student network joining students of different intakes.

Module 5: Master Thesis (30 ECTs)

Module 5 (THESIS) will include the initial steps to write a short project of Master Thesis which has to be approved by the Master Academic Committee and the conduction of a research work in

theoretical, experimental or applied Nuclear Physics with the direction of one or more advisors from one or more Universities (works with coordinate tutors from two partner Universities, or from one University and one associated industrial/host institution, will be encouraged). This module includes the writing of the Master Thesis and the public defense of the achieved results. The student will present and defend the Master Thesis in the University of enrollment during S4 and will follow the rules of that University concerning formats, regulations, deadlines, and composition of the Defense Committee. The present project will recommend to include in this committee academics of the other Consortium Universities, experts from the associated members and/or other external experts). In case of failure, an extra opportunity will be given to the student in his/her S4 enrolment University following the local rules for Master Thesis defense. In this case, the inclusion in the "Defense Committee" of an external member from other internal (Consortium) and external (Associated Members) institution is highly recommended.

COURSE DISTRIBUTION

In the following table we list the courses offered in each University for semesters one, two and three each year. This list is made using part of the structures and courses already offered in local Masters with the appropriate selection of matters. Concerning semester 3, only 12 ECTS have to be obtained in regular courses, since 12 ECTS correspond to the internship and 6 ECTS are assigned to a common course (module 3, see below) which is compulsory for all students. Semester 4 is devoted to the preparation of the Master thesis in a host University, research center or company (MOD 5).

MOD. 1 - Basic nuclear physics and tools	MOD. 2 - Advanced nuclear physics (EXP)	MOD. 2 - Advanced nuclear physics (THEO)	MOD. 2 - Advanced nuclear physics (APP)	MOD. 3 - Common Specialized Course	MOD. 4 - Internship	MOD. 5 - Master Thesis

PATH 1: Experiments, instrumentation and large accelerators (approx. 1/3 of the students)

S1: Spain	**Computing and Numerical Methods (6)**	**Quantum Mechanics (6)**	**Basic Experimental and Applied Laboratory (6)**	**Nuclear Structure (6)**	**Atomic & Plasma Physics (6)**
S2: Padova (Italy)	**Radioactivity and Nuclear Measurements (6)**	**Nuclear Astrophysics (6)**	**Heavy-Ion Reactions (6)**	**Accelerator Physics (6)**	***And 1 to 2 courses **) among*** **-Advanced Laboratory (6) -Sub Nuclear Physics (6)**

					- Introduction to Radiation Detectors (6) -Astroparticle Physics (6)
S3: Caen (France)	**Research Internship (12)**		**Common Advanced Course (6)**	**Experimental Nuclear Physics (12) ***	
S4: Spain, France or Italy	**Master thesis on experimental nuclear physics, instrumentation large accelerators (30)**				

* Experimental nuclear physics includes: design of nuclear experiments, ions and sources, metrology, and Monte Carlo simulations.

** If two courses are chosen here one of the previous four should be removed

PATH 2: Theoretical nuclear physics (approx. 1/3 of the students)

S1: Spain	**Computing and Numerical Methods (6)**	**Quantum Mechanics (6)**	**Basic Experimental and Applied Laboratory (6)**	**Nuclear Structure (6)**	**Atomic & Plasma Physics (6)**
S2: Spain	**Introduction to Nuclear Reactions (6)**	**Relativistic Quantum Mechanics (6)**	**Hadronic Physics (6) or Nuclear Astrophysics (6)**	**Weak Interactions (6)**	**Many-Body Theories in Nuclear Physics (6)**
S3: Caen (France)	**Research Internship (12)**		**Common Advanced course (6)**	**Theoretical nuclear and atomic physics (12) ***	
S4: Italy	**Master thesis on theoretical nuclear physics (30)**				

* Theoretical nuclear and atomic physics includes: advanced nuclear theory, density functional theory and applications, and fundamental interactions

PATH 3: Applications and small accelerators (approx. 1/3 of the students)

S1: Spain	**Computing and Numerical Methods (6)**	**Quantum Mechanics (6)**	**Basic Experimental and Applied Laboratory (6)**	**Nuclear Structure (6)**	**Atomic & Plasma Physics (6)**
S2: Catania (Italy)	**Nuclear Reaction Theory (6)**	**Accelerator Physics and applications (6) / Nuclear and subnuclear Physics Laboratory (6)**	**Medical Physics (6) / Archaeometry (6)**	**Advanced Nuclear Techniques applied to Medicine (6) / Environmental Radioactivity (6)**	**Nuclear Astrophysics (6)**
S3: Caen (France)	**Research Internship (12)**		**Common Advanced course (6)**	**Applications for therapy (12)***	
S4: Spain, France or Italy	**Master thesis on applications and small accelerators (30)**				

* Applications for therapy includes: physics of medical devices, dosimetry and radiation protection, basics of radiotherapy.

Those students fulfilling 42 ECTS corresponding to Module 2, all of them of a certain path, together with the completion of all the other modules, will receive the degree with the specialization corresponding to the path chosen. If a student fulfills 42 ECTS in Module 2 from different paths, after the completion of all the ECTS corresponding to each other module, the student will receive the degree, but without specialization. All path changes should be asked by the students with sufficient advance and should be approved by the Academic Committee.

Courses will be taught in English. Students will be provided with the appropriate academic material in English.

It is important to note that **in addition to the participant Universities, the associated Labs and Companies can be the hosts for internship and Master Thesis development**.

In coordination with some of our associated partners the master program will offer extra-curriculum activities. For instance, in the running master a two-week internship was offered on nuclear physics instrumentation at the main facilities of the company CAEN Sys and CAEN Lab. in Viareggio (Italy),,a one-week internship was offered to work on application to therapy at the Hospital HVM in Seville (Spain) and a four-week internship was offered to work within the nuclear fusion group at CNA in Seville(Spain), and participation was offered to all the interested students to a

one-week summer school in Cabourg (France), https://lisa-itn.web.cern.ch/node/112 . The interested students in path 3 were also offered participation to a two-days mentoring event in Cherbourg for the career of women scientists in nuclear science organized by the WiN network https://win-global.org/. We continue working with our associated partners to open more possibilities of extra-curriculum internships for our students.

These extra-curriculum activities play a major role in the building of the students' entrepreneurship and leadership skills. We will provide national language courses to foster the integration of students along their mobility. Additionally, we promote every year our students to undertake summer internships in any of our associated partners.

Finally, it is worth mentioning that **regular opportunities (meetings of the Academic Committee and Quality Committee) will be scheduled to critically and constructively identify where the content and the coherence of the study programme, the learning outcomes, or any other aspect of the NucPhys, can be improved**. The inclusion of students and industry/research facilities associated partners in the Quality Committee will facilitate to accommodate the NucPhys to new academic/industry needs, if necessary.

Mobility of students, academics, and administrative staff

Students

As stated before, the joint programme will be accredited in a first instance by USE, UCM, UB, and UniCaen. Therefore, these are the four student-enrolling HEI, whereas UniCT and UniPD will receive NucPhys students only on a mobility basis. These two Universities will enroll also our students in their respective Master and deliver the corresponding Diploma to successful students. USE will be the single entrance university at semester 1, with a single administrative entrance point at the master secretariat site at the USE International Graduate School.

The programme boosts student mobility (see **Figure 5** for the student's physical mobility scheme). During the first programme year, students will enroll at USE. They will spend S1 at USE with one subject also at UCM. Then students will split according to the Path chosen (see below the mobility in the three specialization paths). S3 will be a second meeting point where all students will come together at UniCaen (France) to finally split again in S4 according to the choices of each student.

With this mobility scheme, a NucPhys student will have a minimum of one period of physical mobility (6 months) at each of the countries of the partner institutions.

The mobility in the three specialization paths:

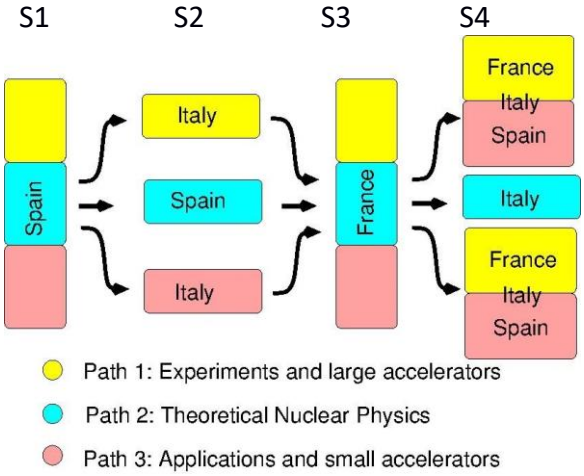
PATH 1: Experiments and Instrumentation in large accelerators. Students following this path will start in Seville for S1, next go to Padova for S2, then to France for S3 and, finally, to any of the three countries for the Master Thesis in S4.

PATH 2: Theoretical nuclear physics. Students within this path will start in Seville for S1 & S2. During S2 they will also visit UB. Then, students will go to France for S3 and finally will go to Italy for the Master Thesis in S4.

PATH 3: Applications and small accelerators. Students within this path will start in Seville for S1, next go to Catania for S2, then to France for S3 and, finally to any of the three countries for the

Master Thesis in S4.

Figure 5. NucPhys students physical Mobility scheme



Teachers

The Council conclusions on enhancing teachers' and trainers' mobility[4] invite Member States to motivate education and training institutions to embed teachers' and trainers' mobility in their learning, development, and internationalization strategies.

NucPhys will promote mobility of teachers to:

- Contribute to the development of transnational teaching teams and facilitate the joint organization of the course's teaching.
- Exchanges of views and experiences among peers and close cooperation between them
- Foster inclusion, equity, high quality education and training, pedagogical innovation, and better learner achievement
- Make them highly competent and motivated teachers and contribute to their professional development
- Promote collaboration in research and joint project's preparation in the thematic of the master's degree.

The Erasmus+ mobility for teaching programme, together with other funding opportunities such as the "Teachers Academy"[5] will be promoted within NucPhys. In addition, blended mobility will be encouraged, for example by using with a Collaborative Online International Learning (COIL)

methodology that connects students and professors in different countries for collaborative projects and discussions as part of their coursework.

Administrative Staff

Mobility of non-academic staff is also a priority of NucPhys. A specific exchange programme, supported by Erasmus +, has been already set up, which will support the mobility of people in charge of NucPhys administration. The objective is to strengthen the work within the administrative team in charge of NucPhys, and to increase the impact and capacity of transformation of NuPchys activities and initiatives by fostering peer-to-peer learning, exchange best practices, lessons learnt and innovative ideas.

3.2. Credits

NucPhys uses ECTS, awarding credits based on defined learning outcomes and their associated workload. The degree programme has a workload of 120 ECTS (60 ECTS per year), whereby one credit is the equivalent of 25 to 30 hours of study, in line with Bologna practices across the EHEA, on the basis of the ECTS Users 'guide.

The use of ECTS by all partners in Europe and most outside Europe makes it possible to create and document learning pathways, allowing better flexibility and comparability. The allocation of workload has been jointly agreed and distributed effectively and equitably for students according to ECTS no matter what their mobility pathways will be in different modules according to NucPhys study plan.

3.3. Workload

See point above for general workload. Internal joint and individual Quality Assessment systems will monitor the actual workload and the average time that students require to finish the whole programme.

4. Joint Admission and Recognition

4.1. Admission

All NucPhys partner universities have internal procedures for admission and selection of students (see **Annex 7**). Based on these official documents, the entry requirements and admission criteria for NucPhys programme have been established and are common for all students.

They will be found together with the joint application procedure on the future master website, as well as the Student's Handbook (see additional **Annex 16**). The general outline of the application and selection processes is illustrated in **Figure 6**.

Figure 6. NucPhys diagram of the tentative schedule of the application and selection process

December	January	February	March	April
Submissions of documents up to deadline	Review of submissions by administrative services	1st round (c.v. evaluation)	2nd round (interviews)	Publication of results

Student access profile and minimum requirements for access to the selection process

Profile:

General requirements for access:

- A university qualification corresponding to bachelor's in physics, Chemistry or Engineering (Materials, Mechanical, Structural, Civil, Aeronautical, Naval) according to the Bologna framework. Any other kind of scientist or engineer with a background related to the objective of NucPhys is also welcome.
- Language skills: English, candidates from countries where English is not one of the official languages, must demonstrate their knowledge of English by proving that they have received their education in English or with a certified language level equivalent to B2 using the CEFR (Common European Framework of Reference for Languages).
- Commitment in writing to full-time study for the two-year period of the Masters Course.

Application procedure and documentation

All applications for admission will be submitted online, through the official application system of NucPhys website, which will be hosted on NucPhys web portal (see additional **Annex 17** for a template of the application form).

The following supporting documents will be uploaded into the application system:

1. Copy of a valid ID document (passport, identity card, etc.). In case of dual nationality, copy of a second passport/ID card proving the second nationality.
2. Photo.
3. Copy of the official university first cycle qualification from a HEI (Bachelor-EQF level 6, or equivalent) and transcript of academic records.

   Considerations about the qualifications:

   a. For students coming from EHAE universities (including the six NucPhys university partners), bachelor's degrees will be automatically recognized, according to the Lisbon convention and NucPhys Co-operation Agreement (see Annex **2**).

   b. Students with a bachelor-equivalent qualification issued by a non-EHEA HEI must provide a document issued by their university that certifies the student level of studies and stating that the diploma allows the student to access to Master studies in the student university country. Students will be required to present officially certified copies and translations into English of the student's diplomas and grades and an official certificate of the ECTS content of the subjects and of their position within their corresponding cohort. Successful admission to NucPhys does not imply that the applicant's previous qualification has been validated to a comparable EHEA qualification entitling rights or granted recognition for any other purposes than access to the Master's degree program.

   c. If a candidate is in the process of obtaining the Bachelor's degree, the applicant can apply for the admission. The applicant must present a letter, written by his/her university, stating the expected date of graduation and a detailed transcript of records.

4. Proof of B2 (CEFR) English level (accepted certificates are University of Cambridge Certificates, TOEFL, IELTS, ACLES, among others).
5. A complete and updated curriculum vitae in English (the Europass CV is recommended).
6. Motivation letter from the student explaining why she/he has selected the Master and describing purposes and interests.
7. Recommendation letters from two referees, of which at least one academic.
8. [OPTIONAL] Any other documents characterizing applicant's credentials, like research memories, mathematical competitions diplomas, etc.
9. Any other documents characterizing applicant's credentials, like research memories, mathematical competitions diplomas, etc.

Selection Process

After closing the deadline for applications, the consortium's Selection Committee will evaluate them. The admission policy is intended to ensure equal opportunity of access to higher education for qualified European and Third-country students. In the first instance the Selection Committee selects those students who meet the Admission Requirements. Those candidates for the Master who meet the Admission Requirements will be ranked with a maximum score of 100 according to:

a) (up to 30) Academic excellence.
b) (up to 3) Relevant work experience related to the field of the Master Course.
c) (up to 5) Student motivation to undertake the Master and relevance to her/his professional development.
d) (up to 10) Recommendation from the references.
e) (up to 2) Others.
f) (up to 50) Individual interview on-line, including language skills and relevance of the student's background to the field of the Master Course.

There will be a two-step selection. In a first round, items a-e will be scored (up to 60 points) independently by three different members of the Selection Committee in order to avoid individual bias. According to this evaluation, approximately the best 50 applicants will be selected for the second evaluation round that will be a personal interview, item f), with one or several members of the selection committee. In this interview the basic Physics and Mathematical background of the applicant, his/her English level, and actual motivation will be evaluated.
In order to ensure the clearness and transparency of the selection process, every applicant will have the right to know their final position according to the following scheme:

-Group I: Applications of very good quality (score higher than 75 points out of 100).
-Group II: Applications of good quality (score between 60 and 75 points out of 100).
-Group III: Applications of weak quality (score less than 60 points out of 100).

Finally, the Committee formulates a proposal for candidates who should be accepted into the Master, as well as a reserve list. As soon as the list is approved, students will be informed, by e-mail. They will also be notified by an official letter expressly confirming the student's admission to the Master programme. The letter will be accompanied by a brief description of the Master Course, with express reference to its organization by officially recognized educational entities in the three countries, and any other information that may help to complete the paperwork necessary to obtain visas, official permits, etc.

Public Roadmap for access and admission

The following roadmap is to be publicly available to guarantee the transparency of the access and admission processes:

- Publication of the call for the upcoming academic year on NucPhys website and other means as specified above.
- Submission of candidatures by students (candidatures must be accepted throughout a minimum of a 1-month period)
- Anonymized publication of preliminary list of students accessing the selection process (I.e., complying with the access requisites).
- 15 natural day-period for the submission of missing documents by non-accepted students.
- Anonymized publication of final list of students accessing the selection process (I.e., complying with the access requisites).
- Assessment of accepted candidatures by the Selection Committee.
- Interviews with pre-selected students.
- Anonymized publication of preliminary list of students admitted to the programme.
- Acceptance period for admitted students.
- Anonymized publication of final list of students admitted to the programme.

Equal Opportunities Policy

It is the policy of NucPhys JMD to recruit, hire and train people without regard to race, colour, age, religion, sex, national origin. Balanced gender participation will be encouraged within each selection group (I, II or III). Particular attention will be paid to students with disabilities and/or with fewer opportunities. Students with disabilities or Specific Learning Disabilities (SLD) will be granted with the access to specific tools and services (buddy to accompany students with disability to courses/study rooms/library/examinations, specialised tutoring to develop effective study methods, professional interpreters to provide simultaneous translation during lectures/examinations/appointments with teachers and other didactic or administrative activities for the hearing impaired, video writing software for the visually impaired) in order to overcome barriers and be as independent as possible in all the partner institutions. In Annex 19, the offices of the different universities in charge of help students in this condition. Additionally, NucPhys is taking concrete measures to promote inclusive culture, by providing diversified resources and support schemes (scholarships and tuition fee waivers) to enhance the diversity and strengths of each student.

The Selection Committee, in agreement with the Academic Committee, will have the right to reserve a certain quota of every intake to promote diversity, inclusiveness, and gender equality, taking as example the guidelines from the Erasmus Mundus call for Joint Masters.

As an example, Erasmus Mundus scholarships that this programme has enjoyed since 2017 academic course have been distributed according to the following criteria: for countries with very large population such as China and India, a maximum of three grants were allocated while for the rest of the countries, the maximum number of grants was two, always without prejudice to high academic standards and in order to ensure geographical diversity among students.

4.2. Recognition of prior learning

All NucPhys partner universities have internal regulations and procedures for the recognition of qualifications and periods of study (including the recognition of prior learning) (see **Annex 8**). NucPhys accepts the recognition of qualifications and prior learning, as well as professional experience, for NucPhys accredited Master's, or non-accredited course work. The number of credits recognized is in function of the QF- EHEA level of studies conducted and of their compatibility with the Joint Master course contents, within the limitations of in force national regulations on academic recognition.

The principles and tools steering academic recognition in NucPhys are based on:

- The Lisbon Recognition Convention and its subsidiary texts: *Convention on the Recognition of Qualifications concerning Higher Education in the European Region*. Available at https://rm.coe.int/168007f2c7
- The European Recognition Manual, available at Microsoft Word - European Recognition Manual Second Edition FIN 17.3.2016.docx (enic-naric.net)
- The QF-EHEA framework and the ESG (European Standards and Guidelines for quality-assurance in higher education) provided for the European Higher Education Area, available at: Microsoft Word - AppendixIII.docx (ehea.info) ; European_Standards_and_Guidelines_for_Quality_Assurance_in_the_EHEA_2015_MC_613727.pdf
- The ECTS Users' Guide that provides the framework for student mobility with its respective documents, namely guidelines on the Learning Agreement. Available at ECTS users' guide - Publications Office of the EU (europa.eu)
- The DEQAR database provided by the European Quality Assurance Register for Higher Education (EQAR), available at Database of External Quality Assurance Results - EQAR
- The Council Recommendation on automatic recognition, available at Council Recommendation of 26 November 2018 on promoting automatic mutual recognition of higher education and upper secondary education and training qualifications and the outcomes of learning periods abroad (europa.eu)

Based on the above references, NucPhys has defined a framework for academic recognition (see co-operation agreement **Annex 2**), with the aim of reducing existing administrative barriers and obstacles in order to promote academic recognition of qualifications and credits earned in any NucPhys university. The overarching objective is to promote flexibility of learning and mobility of students, with smooth academic recognition based on mutual trust between Institutions and the European principles on higher education and its quality assurance, underpinned by the objective of equality and transparency of processes.

Within the Agreement, Academic Recognition is defined, in this agreement and its Annexes, according to the Lisbon Recognition Convention and the 2018 Council Recommendation on automatic mutual recognition, as an overarching process that refers to:

- Automatic recognition for access in the admission process, based on the key principle that a higher education qualification awarded in one Member State is automatically recognised at the same level for the purpose of accessing further studies at any other NucPhys partner Institutions, both without adding a specific recognition procedure and without prejudice to the hosting Institution for setting specific evaluation and admission criteria for specific programmes.

- Recognition of learning periods abroad: Outcomes of study periods abroad will be fully recognised by NucPhys home Institution, as agreed beforehand in a learning agreement and confirmed in the transcript of records, or a certificate of completion of the study period, in line with the ECTS system.
- Recognition of prior learning and work experience: Learning outcomes from formal education or non-formal and informal learning, as well as work experience, may lead to full or partial recognition for the degree that the student is completing or will complete and seeks to get recognised, according to the process of NucPhys home and/or host Institution as well as the national regulations in force.

NucPhys co-operation agreement (**Annex 2**) contains the basic principles for academic recognition within NucPhys, including in its annex III the basic rules for automatic recognition of qualifications for access and admission, and recognition of learning periods abroad, prior learning, and work experience.

The agreement also defines that NucPhys Academic Committee will ensure coordination between the authorities responsible for academic recognition at the NucPhys partner regarding NucPhys Master, and will be in charge of:

- coordinating with the academic bodies responsible for recognition at each NucPhys partner university, to promote flexible and automatic academic recognition within NucPhys. The Academic Committee will assist the NucPhys Selection Committee, when necessary.
- providing and disseminating information about academic recognition in NucPhys.
- any other task related to academic recognition within NucPhys, if needed.

NucPhys has also defined a common set of academic recognition application forms to be used by the students when applying for academic recognition. This document is provided as additional **Annex 18**.

5. Joint Teaching, Learning and Assessment

All NucPhys partner universities have internal regulations and procedures for teaching and assessment of students (see **Annex 9**).

5.1. Teaching and Learning

NucPhys programme and academic staff are committed to improving the quality of teaching, being open to new innovative methodologies. An ambitious master programme should be based on highly competent and motivated teachers and trainers. NucPhys will also promote the exchange among the different actors in teaching: professors, invited scholars, experts, and students (see section 7.1). The different partners will ensure that the academic staff is and continue to be composed of highly motivated researchers with solid experience in teaching.

Aligned teaching

NucPhys will promote student-centered learning. Careful consideration of the design and delivery of study programmes and the assessment of outcomes will be provided. Regular monitoring, review and revision of NucPhys Master is permanently done to ensure it is up-to-date to guarantee that NucPhys content is in the light of the latest research in the field of Nuclear Physics. In addition, the student's workload, progression and completion, students' expectation, needs and satisfaction and the learning environment and support services are also assessed in a regular basis to set corrective measures when necessary.

NucPhys programme ensures an appropriate and constructive alignment between learning outcomes, learning and teaching activities and the assessment procedures. The course catalogue will provide reliable up-to-date and quality assured information of the degree programme. This information will be available to students throught the NucPhys webpage and the Student's Handbook (see additional Annex 19). Together with the Student's Handbook, each semester (and course within it) will have a complementary guidebook describing the context within NucPhys programme and overall objectives. According to the Bologna strategy and the TUNING methodology, the guidebooks will also include the workload, intended learning outcomes, and aligned contents, teaching and learning methodology, assessment methods and criteria, as well as any other necessary information (see Annex 5 and section 6). Specific attention will be paid to the guidebooks for Traineeships and Master Thesis. The Student's Handbook is to be approved by both the Internal Quality Committee and the Academic Committee. This information will be made available to students at the beginning of each semester.

The programme will start with an introductory week and a welcome ceremony. In this wellcome ceremony, local academic coordinators will introduce themselves and the content of its corresponding semester/subjects. This presentation aims to help the student prepare for learning, become familiar with the teaching staff, and know what is expected from them in terms of teaching and assessment.

At the beginning of each semester, the hosting University will prepare similar activities within a welcoming week. During this introductory stage, students will be provided with learning materials to prepare themselves for each semester's subjects. Feedback from students on these resources will be welcomed to foster a student-centred approach.

Active Learning

Research evidence supports the idea that active learning improves learning outcomes. In active learning, students are required to do meaningful learning activities and think about what they are doing.

NucPhys includes active teaching and learning methods that engage students in the learning process in order to increase their motivation and build critical thinking, problem-solving and social skills. They will target large and small groups of students, as well as individual learning.

In addition to the traditional lectures, "In classroom" active learning methods will be used. Some, non-exclusive, examples, are:

1. Seminars and tutorials (usually more informal, with the possibility of open discussion)
2. Problem-based learning and project/challenge-based learning
3. Flipped learning

"Out of classroom" active learning will include, among others:

1. Individual learning, with student's support through NucPhys virtual environment and academic advice
2. Laboratory and practical learning of experimental methods and techniques
3. Summer internships will be promoted as extra-curricular activities.
4. Exposure to the reality of professional life outside university and the future labour market needs, in collaboration with associated partners, and invited experts. This will be achieved through, for example:
    a. Visits to associated centers
    b. S3 Internship
    c. Professional-oriented and challenge-based master thesis (project/challenge-based learning)
5. Exposure to research, through research S3 internship and research-oriented and challenge-based master thesis (project/challenge-based learning), in collaboration with invited experts.

Finally, we would like to highlight two examples of active learning in the first module (see **Annex 5**). In the course on computing and numerical analysis, students will receive few teaching classes with the fundamentals on computing, including different programming languages, and then projects will be assigned to the students organized in small groups. These projects are intended to be worked out by themselves but in collaboration with mates. A small introduction to collaborative computing tools will be also provided. Such collaborative tools and an online log will help professors to evaluate continuously the progress. Students will also decide the programming language to develop the project, usually considering which one will be more useful according to their future employment perspectives. On Basic Experimental and Applied Laboratory, students will have an open-lab period after the completion of the compulsory lab sessions. They will find extra or complimentary voluntary lab sessions with state-of-the-art equipment. It is an early opportunity for the student to start a specialization. They will also have the opportunity to recover those lab sessions they could not attend in the normal period.

Module description tables provided in **Annex 5** include the module workload, general objective, intended learning outcomes, the main module contents, as well as the teaching and learning methodology and assessment methods.

5.2. Assessment of students

Fit-for-purpose assessment

Assessment is a powerful educational tool; it cannot be seen only as a technical task. It influences the judgements of students and teachers about what is of most importance in the curriculum. The effects should be positive and justify expectations of students, teachers, and the curriculum.

According to Aligned Teaching principles, NucPhys will promote “Fit-for-purpose” assessment methods of learning outcomes. These methods are well-suited to what is being assessed (i.e., the capabilities at the level required for the role) in the particular context (i.e., functional or subject matter area). The assessment will concern the ‘object’ under study and will provide students with opportunities to give evidence of their skills and competences related to the intended Learning Outcomes.

In NucPhys, different assessment approaches will be used:

- Content-based assessment refers to tasks that primarily concern facts about the object under study.
- Competence-based assessments refers to the assessment of intended learning outcomes that test the learner’s ability to use these facts.
- Impact-based assessments weights the ability of the learner to use these competences in a real-life situation to create a change or solve a challenge.

This focus on the intended learning outcomes calls for the preferably use of ‘continuous/formative assessment’, which evaluates student progress throughout the programme of study rather than a “single/summative assessment” at the end of a programme.

A range of assessment methods will be used across the courses. Some, non-exclusive, examples, are:

- Time-limited open-book/take home examinations
- Pre-release of materials for students to work on prior to synchronous assessment
- Asynchronous online assessments.
- Essays
- Project assignment
- Reports (i.e., a research-based report, a research-informed position paper, or a "in company report" for assessment of traineeships)
- Proposal documentation, research reports, and oral presentations, among others.

Module description tables provided in **Annex 5** include the module workload, general objective, intended learning outcomes, the main module contents, as well as the teaching and learning methodology and assessment methods.

Grading System and assessment criteria

NucPhys joint degrees will use a grading system with an assessment scale from 0 to 100%. The consortium has approved an equivalence table between this system and the corresponding EHEA and national systems (**Table 5**). This will allow a fluid communication among the teachers and administrative staff of the partner universities concerning students' transcript of records.

In order to ensure coherence across the partnership in assessing students and besides promoting mobility, the evaluation of the internship (12 ECTS) is fully common, with a public defense and a jury composed of the academic representative of the Consortium universities. On the other hand, although the master thesis is evaluated by a committee in each partner university, the Academic Committee will promote master thesis co-supervised jointly by staff from different partners and/or in collaboration with associated centers. It will be encourged as well that evaluation panels include at least one representative of a different Consortium university or an associated centre.

In general, to pass mark on every course, students much achieve 50% and above, unless specified by the academic regulation of a partner university. Module description tables provided in **Annex 5** include the module workload, general objective, intended learning outcomes, the main module contents, teaching and learning methodology, and the assessment methods. Once deployed, the course guidebooks will also include the % weight of every assessment on the total course score.

NucPhys will establish a transparent compensation policy before the start of the joint programme. In general, students failing to pass individual taught modules will be able to present for supplemental examination or re-submit required work. While at a host institution, local policies for re-siting local master's level examinations will apply. These include courses, internship and Master Thesis.

Table 5. NucPhys grading system and its equivalence to the EHEA and national grading systems

	Fail	Sufficient	Satisfactory	Good	Very Good	Excellent	Exceptional
EEES	FX-F	E	D	C	B	A	A+
NucPhys	0-49 %	50-59%	60-69%	70-79%	80-89%	90-100%	100% Cum Laude
Spain	0-4,9	5-5,9	6-6.9	7-7,9	8-8,9	9-10	10 MH
France	0-9,9	10-10,9	11-11,9	12-13,9	14-15,9	16-17,9	18-20
Italy	0-17,9	18-22	23-25	26-27	28-29	30-30L	30L
Italy - Graduation marks		66-83	84-94	95-102	103-109	110-110L	110L

Assessment of mobile students

There are not specific provisions to NucPhys outgoing mobile students. They will be assessed following the same assessment methods, regardless of the NucPhys partner university where they follow the joint study programme.

5.3. Improving teacher's competences

NucPhys consortium fully assures the competence of our lecturers, who are highly motivated researches in the field of Nuclear Physics with a wide experience in teaching and researching. In addition, the consortium encourages scholarly activities to strengthen the link between education and research, the innovation in teaching methods and the use of new technologies.

In order to accommodate the needs of the multicultural students, academic staff will adopt a more international approach, embracing shared and innovative methods for teaching and studying. Academic staff of NucPhys will meet at regular programme events (i.e. high specialised course, Master Thesis examination, or opening/graduation ceremonies) to discuss course content, teaching and joint supervision methods, and evaluation practices, with the aim of achieving greater harmonization in grading the learning outcomes. This will provide consistent and sustainable practices to the academic staff of the consortium.

The visiting scholars and industry guess lecturers and partners for internships will add new methods of teaching, or produce teaching materials to complement. They will be consulted for shaping the programme to the labour market/research needs, will participate in Master Thesis, and will have a representative in the management and quality control bodies. This will enhance complementarity and multidisciplinary and enrich the teaching teams.

5.4. NucPhys virtual environment for learning, teaching, and assessment

There will be a common space in the coordinator University for all students and professors. It will be a virtual environment for teaching and learning. It will provide virtual classrooms, e-learning/assessing spaces for students, and teachers as well as collaborative workspaces (i.e., for teacher's transnational teams to organize their teaching, for student's collaborative projects, for COIL projects among teachers and students at different NucPhys universities).

5.5. Tackling the diversity of students

In line with EU policies on equality and non-discrimination as well as related EU strategies and policies in Education, Research, and Innovation, NucPhys is committed to foster diversity, inclusiveness, and gender equality. This will be tackled also during their learning process and the day-a-day of the students.

As stated before, NucPhys focusses on student-centered learning and teaching. It will respect and attend to the diversity of students and their needs, enabling flexible learning paths; flexibly use a variety of pedagogical methods; regularly evaluate and adjusts the modes of delivery and pedagogical methods; encourage a sense of autonomy in the learner, while ensuring adequate guidance and support from the teacher; promote mutual respect within the learner-teacher relationship and have appropriate procedures for dealing with students' complaints.

Although education is full-time, there will be opportunities for a flexible organization of learning, teaching, and assessment activities to accommodate students with different profiles and/or needs (i.e., people with caring responsibilities or people with disabilities).

All university partners have programmes to address students with special needs, as part of the student support described in section 6.

6: Student Support

Joint NucPhys student support services

To ensure the best higher education experience, NucPhys will provide students, regardless of their location, with seamless access to the participating HEI services, including both joint NucPhys services and individual services at every partner university.
All these NucPhys joint and individual university services will be included in NucPhys Student's Handbook, which will be available online in NucPhys web page (see additional **Annex 16**).

The following NucPhys joint students' support services, guides and programmes are worth mentioning:
Support Services:

1. NucPhys academic governance and management structure, with the Academic Committee, the Selection Committee, Internal QA Committee, and Secretariat, and associated NucPhys and local bodies. A single email address and a list of contacts will be provided in NucPhys web page (see section 1.2 for a detailed description). It should be reminded that students are represented on the main committees of NucPhys.
2. Students' network, composed by alumni and current students, and supported by the Secretariat for purposes of dissemination and social media, will provide mentoring to current students, and networking and advice to find a job.

Support guides and programmes:

3. Students will assist to a common welcome ceremony for all of them at the beginning of the Master. This ceremony will be jointly organized by all the partners and will provide basic information for the mobility and main support that students will receive following each Path. A selection of alumni will be invited to introduce themselves to the next NucPhys intake, enforcing their integration in NucPhys students' network. Welcome weeks and sessions will be organized at every partner university to facilitate the initial student's integration, including guided visits to the university facilities.
4. Apart from NucPhys student's Handbook, each hosting HEI will provide a local guide with information on services, expenses, and mobility help prior to the arrival of the student.
5. UniPD and UniCaen also offer students accommodation at their University residences at a convenient low fare.
6. A mentoring programme to connect new students with a tutor (voluntary alumni, second-year students of the master or professors). Potential tutors will be encouraged to enroll and to have periodic discussions with students on which skills are expected to be evaluated and how, evaluation systems, bureaucratic procedures, etc.
7. Language courses will be offered to students at the beginning of each semester at each NucPhys hosting partner, starting with a Spanish course in first semester.
8. A joint graduation ceremony will be organized in one of the partner universities on a rotational basis and in a mixed format: face-to-face and online. The idea is to maximize the number of students attending from both coetaneous intakes, but also alumni and representatives of all partners.

Individual partner universities support services

Table 6. Links to students support services at every NucPhys partner university

USE	https://sacu.us.es/
UNICAEN	https://www.unicaen.fr/welcome-to-unicaen/
UNIPD	https://www.unipd.it/en/course/student-centred-services https://www.unipd.it/en/studying-padova-services
UCM	https://www.ucm.es/informacion/ https://www.ucm.es/la-casa-del-estudiante/ https://www.ucm.es/portaldetransparencia/area-academica/
UNICT	https://www.unict.it/servizi
UB	http://www.ub.edu/sae/landing/index_en.html

7. Resources

7.1. Teaching, Administration and Services Staff

Actors in teaching

NucPhys purpose is to train students in the different basic aspects of Nuclear Physics: theory, experiments and applications, providing them all necessary skills and state-of-the-art knowledge to develop a successful career both continuing in academia and research with a PhD or growing an interesting profile for research and innovation top enterprises worldwide. To achieve such high standards, we join forces from all parts of the consortium gathered In the following teams:

- Academic Staff/Researchers from NucPhys partner Universities, their departments and research centers. They are experts in research and innovation in the master's interdisciplinary fields, and in transversal skills development.
- NucPhys Associated Partners, composed by several of the main research facilities in the world but also hospitals and companies, will get the students closer to the real work and participate in the teaching and assessment activities in general, with emphasis in the traineeships and master thesis activities.
- Invited experts, both from the academia, research institutions, public and private institutions, will complement the teaching teams with their research and innovation expertise, and labour market experience.
- NucPhys students, could also participate, on a voluntary basis, on the teaching activities. Some examples are giving below:
    - Peer-assisted study sessions, led by volunteer students studying the same subject, who act as facilitators. Sessions will generally be based around a specific area of study. This active teaching & learning methodology helps to consolidate and build on the existing knowledge through discussion with other students in an informal and supportive environment.
    - Second-year students can help new mates through the mentoring program mentioned in section 6.
    - Students from the first year will be invited to attend, preferably physically, the internship defense of second year mates. They could also attend (physically or remotely) the Master Thesis dissertations by second-year students. This will provide the opportunity of learning about the internship and Master Thesis topics, presentation, assessment, and communication skills. More importantly, it will strengthen the connection among all our students, promoting teamwork and helping students from very different cultural backgrounds to overcome daily life challenges.

NucPhys consortium fully assures the competence of our lecturers, who are highly motivated researches in the field of Nuclear Physics with a wide experience in teaching and researching. In addition, the consortium encourages scholarly activities to strengthen the link between education and research and the innovation in teaching methods and the use of new technologies. Their involvement in research is crucial to achieving the highest standards possible and to serve as reference for the development of high-quality research and training in the joint programme.

Annex 10 includes the CVs of the main academic staff that will be involved in NucPhys.

Administration and services

The governance and management structure of NucPhys and its coordination with NucPhys and local management and internal monitoring bodies is described in **section 1.2**.

7.2 Facilities and material resources

The consortium put at the disposal of NucPhys students all the facilities and resources available, both the jointly created NucPhys webpage and the individual facilities and resources of every university partners.

In addition, for each academic course, a common space on the virtual learning platform of the coordinating University is created. In this space, all students (first and second year) have access, so that serves as a common forum for dissemination of important information and to put them in contact.

The consortium universities all have high-quality facilities for students learning, research and innovation activities and say-a-day. For a more detailed information, see additional **Annexes 16** (Student's Handbook) and **19** (list of facilities provided by every partner university).

In addition to those of Annex 19, we would like to include all research facilities associated with our local HEI's, most of them associated centers that largely participate in our joint programme:

University of Caen-Normandie has close links with GANIL, including the high intensity rare ion facility SPIRAL2 under construction, is one of the four largest laboratories in the world dedicated to research using ion beams. SPIRAL2 is complemented by two equipment of excellence (EQUIPEX), the next-generation spectrometer S3 and the experimental room for physics at low energy DESIR, both selected and financed by the National Agency of Research (ANR), led by the French Ministry of Higher Education and Research. Since the very beginning, GANIL has actively participated in European projects in which it cooperates with many laboratories from the European Union and beyond. (http://www.ganil-spiral2.eu/). In addition, Caen University is also strongly linked to the project ARCHADE (resource and research center in hadrontherapy) open in 2019. This center will have two independent superconductor cyclotrons: a protontherapy cyclotron for treatment, and a C400 cyclotron for ion acceleration up to Carbon for research purposes in hadrontherapy (physics, radiobiology and clinic aspects). The physicists implied in the Consortium are responsible of the research programs in physics at ARCHADE as well as in the interdisciplinary programs for radiotherapy treatments.

University of Padua has a long and well established history in Nuclear Physics research which is strongly related to the Laboratori Nazionali di Legnaro (LNL) that is one of the four national labs of the Italian Institute of Nuclear Physics (INFN). The mission is to perform basic research in nuclear physics and nuclearastrophysics, together with applications of nuclear technologies. More than 800 scientists from all over the world are involved in the ongoing research programs. Every day about 250 people work at LNL, half of them being INFN employees (physicists, engineers, technicians....) the remaining half coming from universities and research institutions in Italy and abroad. The laboratory budget is nearly 20 Million Euro per year, half for handling and research, and half for personnel. Strength points are the development of particle accelerators and of nuclear radiation detectors. LNL have been recognized at European level as a Research Infrastructure with Transnational Access. (http://www.lnl.infn.it/).

University of Catania is closely related to the Laboratori Nazionali del Sud (LNS). LNS is one of the four national laboratories of INFN. Founded in 1976 it currently employs about 130 people (researcher and technicians) and associates about 130 people among professors, researcher, PhD and Diploma students from the University. It is an advanced development center for technology and instrumentation. The laboratory budget is about 12 Million Euro per year for direct research, personnel budget excluded. The research activity is mainly devoted to the study of structure and reaction of atomic nuclei bu mean of both a Tandem and a Supeconducting Cyclotron, in collaboration with more than 700 researchers coming from Italy as well as several European and non-European countries. A Tandem accelerator allows an intense activity in Nuclear Astrophysics measuring the cross section of interest for fusion nuclear energy and stellar nucleosynthesis (ASFIN2 project). Among the new projects in fundamental research it is also worth mentioning the construction and operation of a submarine cubic kilometer telescope (KM3NeT) installed at 3500 m depth offshore from Catania, with a long and complex
R&D activity in which the LNS have been deeply involved inside the KM3NeT project (https://www.lns.infn.it/en/research/astroparticle-physics.html). UniCT and LNS beyond the experiments at the frontier of the Nuclear Physics are strongly active in several aspects of Applied Nuclear Physics such as accelerators technology, cultural heritage and Archaeometry with non – destructive techniques (LANDIS and PH3DRA labs), monitoring of Nuclear Waste, Laser Physics for Nuclear Fusion plasma and above all in Nuclear Medicine with a center for eye-melanoma therapy and the projects CATANA, ELIMED, SCENT. The students of NucPhys will be allowed to profit also from an on-going agreement between LNS and Azienda Ospedaliero Universitaria Policlinico di Catania to have a direct experience of applied nuclear medicine.

University of Seville shares CNA with CSIC and Junta de Andalucía. CNA hosts three ion accelerators: Tandem Van de Graaff 3MV, Cyclotron with protons up to 18 MeV and deuterons up to 9 MeV and a Tandem Cockcroft-Walton of 1 MV used as mass spectrometer. In addition, there is a scanner PET/CT for humans, a dedicated accelerator for 14C dating MiCaDaS, and a 60Co irradiator. (http://acdc.sav.us.es/cna/index.php/en).

In the first semester, students can benefit from a visit to one of the two University Hospitals of Seville: Hospital Universitario Vírgen de la Macarena (HUVM) and Hospital Universitario Vírgen del Rocío (HUVR). On December 2022, the visit was to HUVM where our students were in contact with last-year residents of the Hospital.

When being at University of Barcelona, they can visit ALBA, a facility co-financed by the Spanish government and the Catalan government. It is a new generation of synchrotron. ALBA is a circular-shaped machine, called a synchrotron that uses arrays of magnets, called insertion devices to generate bright beams of synchrotron light. There are research lines on: Accelerator Computing, Engineering, Experiments on material science mainly. (https://www.cells.es/).

University Complutense of Madrid has close connections to CIEMAT (Centro de Investigaciones Energ.ticas, Medioambientales y Tecnológicas) which is a public research body assigned to the Ministry of Economy and Competitiveness focusing on energy and environment and the technologies related to them. Of particular interest for NucPhys is the Thermonuclear Fusion Device TJ-II which is a heliac-type stellarator, which produces magnetically-confined fusion plasmas. (http://www.ciemat.es/).

8. Transparency and Documentation

Attracting the best students is our main goal.

General provisions

The consortium has already implemented several mechanisms to promote and disseminate research results. All the actions are included in a Communication Plan (CP) which includes targets, objectives and corresponding measures.
Our main target is potential students graduated in Physics or other related areas such as Chemistry, Engineering, Applied Mathematics or similar or any other kind of scientist with interest in Nuclear Physics. In addition, universities with physics departments, international associations in the field of nuclear physics, research centers, laboratories, public and private institutions, companies, scholars and interest groups are also key players that are targeted in our CP.
The aim of the CP is to promote as much as possible the NucPhys master course so to reach a number of potential candidates, but also to disseminate the results obtained under the programme to become a reference in the field of Nuclear Physics education.

The programme will count on the support of the six partner universities. They will contribute to the implementation of a plan that includes (but is not limited to):

- The joint programme will be integrated into the academic offer catalogue of the six partner universities. A summary of all the access requirements, the training catalogue, the modules, and awarding of the joint degree and diploma will be included.
- NucPhys website (see below): A specific page within the NucPhys webpage. All partners commit to having it advertised during the application period. The selection process will be duly advertised along with the course structure and application process information in compliance with the abovementioned communication programme. An anonymized list of selected and non-selected participants will be made available to all applicants (by email or by being published on the Joint Master programme site), including the rank resulting from the selection process of applications (see section 4.1).
- Social media: the social media channels of NucPhys and its partners will be used to actively promote the application period, as well as key landmarks during the academic course. An annual social media campaign will be agreed upon by all partners. All universities commit to having a data protection and image management agreement signed by the students in order to use pictures and video recordings of the programme.
- Sustainably printed leaflets (and potentially, goodies) can be made available for the use of all partners by the NucPhys Dissemination Unit, following the NucPhys visual identity guidelines. These will be generally in English.

NucPhys web page

All the information and documentation related to the joint programme will be available online through NucPhys website, including a public roadmap for access and admission (see section 4.1).

The most important information will be extracted in NucPhys Student's Handbook (see additional **Annex 16**) which will be available in both online and printable versions, including:

- The presentation of NucPhys and the joint master programme.

- General academic information (objectives, participants, job opportunities, structure and content of the curriculum, joint degree, and joint diploma supplement), fees and scholarships, student's rights and obligations, and equal opportunity policy.
- Information and documentation about the main procedures (admission and selection, application for scholarships and recognition of prior learning, enrolment, mobility, traineeships, master thesis, and joint degree and diploma supplement).
- Student's supporting services and facilities (both joint NucPhys and individual university).
- Opportunities to participate in NucPhys, including participation in the governance, peer teaching and assessment, the Student Association, and the Student Network.
- An Inbox for student's feedback, suggestions, and complaints.

Results from the Internal and External Quality reports will be also available through the joint master web page.

Open repository

Hosted in the NucPhys website, an open repository will include, among others:

- Master Thesis projects from students of previous cohorts.
- Summaries of summer internships.
- Summaries of extracurricular activities.
- A selection of testimonials from previous alumni on their experience in NucPhys

Info sessions

- Live info-sessions (online and in-person) at partner universities, including a welcome week at the beginning of the academic year and open-door days. A minimum of one info-session per semester must be organized at each hosting university.
- Introductory sessions will be organized by the teaching teams at the beginning of every semester.

9. Internal Quality Assurance

All partner universities have internal quality assurance systems of programmes (see **Annex 11**).

NucPhys Consortium is perfectly aware of the importance of the Standards and Guidelines for Quality Assurance in the European Higher Education Area and therefore, NucPhys has a joint transnational Internal Quality Assurance System, following the Standards and Guidelines for Quality Assurance in the European Higher Education Area (the so-called ESG; 2015), and considering the Tuning Project Higher Education Structures in Europe (Line 5: the role of quality enhancement of the educational process – emphasising systems based on internal quality culture) and the recommendations in the EUA Guidelines for quality enhancement in European Joint Masters Programmes to comply with the needs of a joint Master's course.

NucPhys Internal Quality Assurance

Internal Quality assessment procedures in NucPhys have been agreed upon by all partners. Joint procedures will be implemented according to the following points:

1. Policy for internal quality assurance and academic governance and management structure.

Our policy for quality assurance will form part of our strategic governance and management, as described in section 1.2. The Internal Quality Assurance Committee ensures the joint programme internal quality assurance and designs improvement strategies. This committee is formed by one academic from each partner university, one representative of the associated partners, and two students of the current edition (one per intake) of the joint programme. This committee will implement all the internal evaluation strategies and mechanisms.

The NucPhys Internal QA Committee is in contact with:

- The Academic Commission, that will decide upon the actions to be taken to improve the weaknesses detected through the Internal QA evaluation. It will be the responsibility of local coordinators to analyze the feasibility of the actions proposed and to follow up its implementation.
- The USE Unit for QA Management, which in turns coordinates the accreditation and following up of the joint degree in contact with the external QA Agency DEVA.

2. Joint procedures and Instruments

The Internal Quality Assurance Committee undertakes annually a coherent set of detailed procedures addressed to the different master's stakeholders involved: students, alumni, teachers, administrative staff, and external stakeholders (associated partners, invited experts, other institutions/companies collaborating in traineeships, etc) regarding:

1. Analysis of academic performance
2. Overall satisfaction assessment
3. Module evaluations
4. Mobility evaluations
5. Traineeships evaluations
6. Master's thesis evaluations
7. Graduate Outcomes
8. Broadcasting the degree

9. Suggestions and complaints
10. Termination of the degree
11. Quality enhancement planning

For each of the procedures, the objective will be specified along with the data collection system, the data analysis system, and the enhancement system for suggesting and implementing improvements to the NucPhys, as well as the available instruments for the procedure.

The tools used to gather information will vary, and will include:

- Semi-structured interviews with the Consortium Academic Committee.
- Interviews with personnel in charge of technical resources.
- Questionnaire for teachers and Tutors of the associated institutions/companies (internships, Master Thesis).
- Questionnaire for students.
- Alumni Survey (important to measure employability).
- Specialists' opinion.

The consortium has already prepared questionnaires for NucPhys students: a first one about the "Teaching quality" which will be sent to the students in order to evaluate each teacher, a second one aiming to evaluate the mobility paths and a third one designed to measure the general assessment once the NucPhys ends.

The information collected in the individual Quality Assurance systems will be reported by each university to the Quality Committee. This committee will use this information not only for the improvement of the quality from one edition to the next one but also for the implementation of immediate measures when necessary. Teachers and students will be directly involved in this exercise due to the composition of the Quality Committee. Additionally, the treatment of personal data and results of each teacher's individual evaluation will be an important issue and it will be treated confidentially. This information will only be available for the Quality Committee and the teacher herself/himself.

3. Internal Quality Calendar, to implement and streamline the internal quality procedures, following the methodology of Deming's quality cycle of Plan, Do, Check, Act (PDCA). It will include a yearly action plan for internal quality enhancement for each of the stakeholder groups separately as an annual "to do"-list which helps that the procedures are implemented in a coordinated way. This ensures that the internal quality procedures are implemented in a coordinated manner by the different NucPhys universities.

External Quality Assurance

NucPhys consortium considers that external evaluation is an essential point for the maintenance of its level of excellence. Thus, the objectives of this evaluation will be:

- To verify whether the Masters Programme has met the objectives for which it was set up and to analyse the extent to which it has done so.
- To analyse the degree of satisfaction among the NucPhys students.
- To identify possible strengths and weaknesses in the Masters Programme.
- To diagnose the strengths and weaknesses of the teachers participating in the Masters Programme.

- To evaluate the content, methodology and strategies used, and to assess their efficiency.
- To evaluate the application of the grading scale, together with the conversion of the grade obtained to the comparative listing and the degree of satisfaction expressed by students assessed in this way.
- To evaluate the success of trained students and alumni of NucPhys.

Quality control will be carried out by an external international committee, composed by two independent and external experts both in Nuclear Physics and Joint Master's Degrees. This evaluation is performed two to three intakes are finished. All the results obtained by the internal evaluation will be available for the external international committee. Full reports by the experts will be published, clear and accessible to all the stakeholders.

Surveys

The surveys among students, alumni, staff, and external stakeholders will allow for the identification of strengths and needs for improvements in the programme design and in the teaching methods. The different forms will be digitised and sent through the Digital Platform to evaluators in a coordinated manner by the Master's Secretariat. In particular, the content of the survey to measure graduate outcomes will be aligned to the EUROGRADUATE[2] survey, a pilot survey funded by the Erasmus + programme.

[2] Eurograduate Project