EL-BONGÓ physics

Work Package 1: Community and Curriculum Development

Report on RLC Communities

Content

Introduction

This report presents Work Package 1 (WP1) – *Preparation progress and outcomes*, implemented during the first six months (M1–M6) of the EL-BONGÓ physics Erasmus+ Capacity Building in Higher Education (CBHE) project. WP1 was designed as a foundational phase to ensure that all elements necessary for the future implementation of the community training program were carefully planned, structured, and aligned with the overall project objectives.

WP1's primary focus was designing and planning a **comprehensive and modular training program** to strengthen research and learning communities in Latin American partner institutions. This involved defining the program's structure, outlining its modules, learning outcomes, and prerequisites, and establishing the interrelations between components through a visual **curriculum map**. This map will serve as a guiding framework for students, educators, and institutional managers throughout the program's implementation.

WP1 is coordinated by the University of Salamanca (USal), with the Universidad de San Carlos de Guatemala (USAC) acting as deputy. Other active partners in this work package included UCV (Venezuela), USFQ (Ecuador), UNAH (Honduras), UNI (Nicaragua), and UT3 (France). Together, these institutions are collaborating to design training programs tailored to each community's local context, academic strengths, and capacity-building needs.

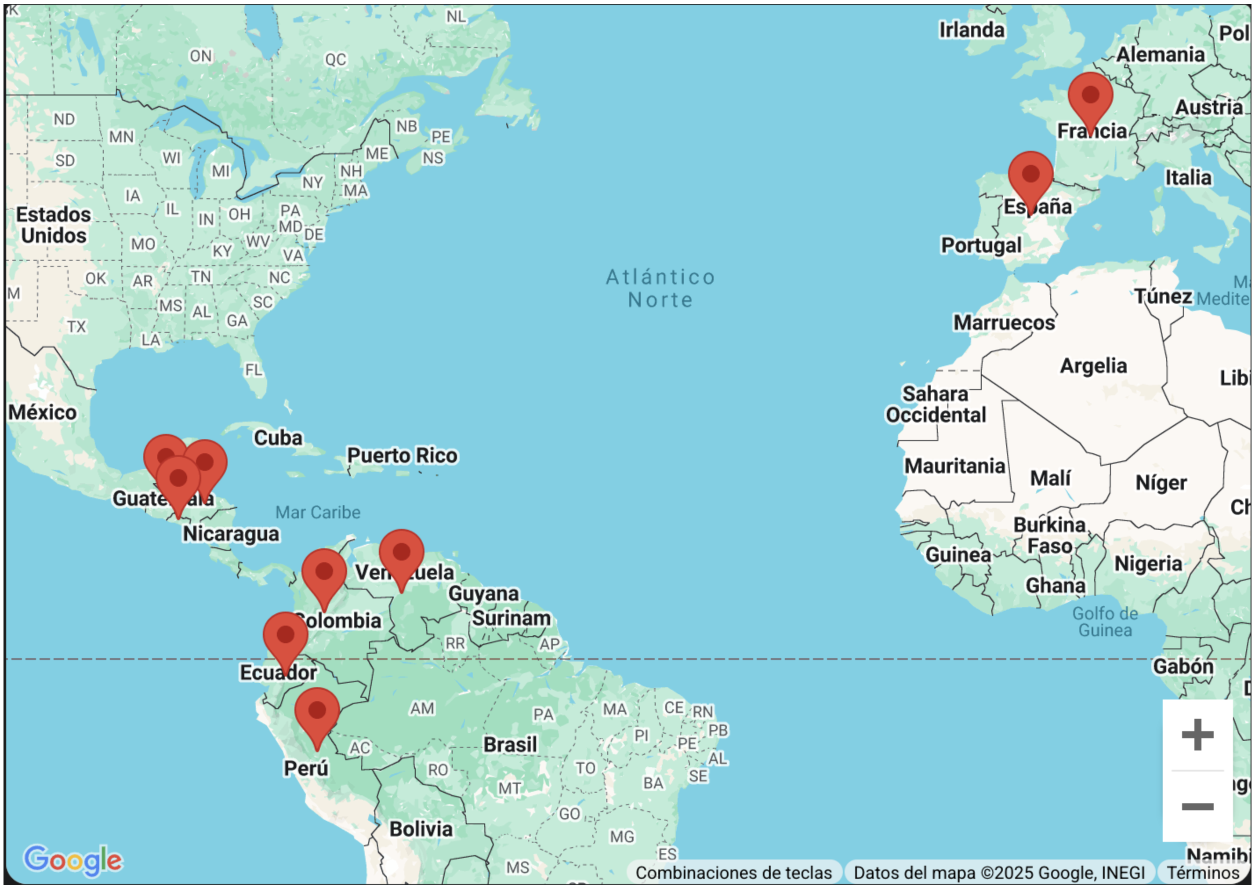
The activities carried out in WP1 have resulted in the following key outcomes:

- A clear **definition of each community**, including membership, leadership, and thematic research focus.
- A **comprehensive training program syllabus** for the research-learning communities, structured to respond to both project goals and local priorities.
- A **detailed curriculum map**, showing the sequencing and interconnection of training modules, learning objectives, and prerequisites.
- A general state of **readiness for implementation** includes identifying necessary infrastructure, human resources, and training materials.

This preparatory phase ensures that the project is well-positioned for the next stages, with a solid academic and operational foundation that supports the core capacity-building mission of the EL-BONGÓ physics project.

Brief overview of the EL-BONGÓ physics project

The ERASMUS+ project *EL-BONGÓ physics* is a unique initiative focused on the digital transformation of higher education in Latin America. It emphasises the importance of virtual research and learning communities alongside open science practices. Built upon the successes of the ERASMUS+ LA-CoNGA physics program, this project aims to create a network of research communities in physics across Central America and the tropical Andean region. The network includes 16 Latin American and European universities from nine countries, all committed to the principles of open science. Four universities are from Central America (Guatemala, Honduras, and El Salvador), and eight are from Colombia, Ecuador, Peru, and Venezuela. There are four European universities, three in France and one in Spain. There are and 13 associated partners (including six leading research centers, three industrial partners, and four multilateral organizations)



One of EL-BONGÓ physics main goals is to build a network of virtual research and learning communities that use digital platforms to foster collaboration among students, educators, researchers, and industry professionals. The project primarily promotes digital education and open science, leveraging advanced digital tools and open-access resources to democratize physics education and research. This focus on digital education offers exciting opportunities for innovation and progress. Another key aspect is the development of practical skills in digital fabrication through FABLab[1] environments and implementing hybrid masters-level courses for research-learning communities.

The proposal includes the creation of four Physics Research and Learning Communities within a network of higher education institutions. These communities will focus on high-energy physics, astroparticles, seismology, artificial intelligence, and computational physics tools. The EL-BONGÓ physics learning environment emphasises innovative digital learning methods based on community research dynamics, flexible curricular ecosystems, and Scientific Diplomacy through collaboration with the Latin American diaspora. Social impact activities such as hackathons and citizen science projects are integrated to enhance educational experiences, foster innovation, promote collaboration, and bridge academic research with real-world challenges.

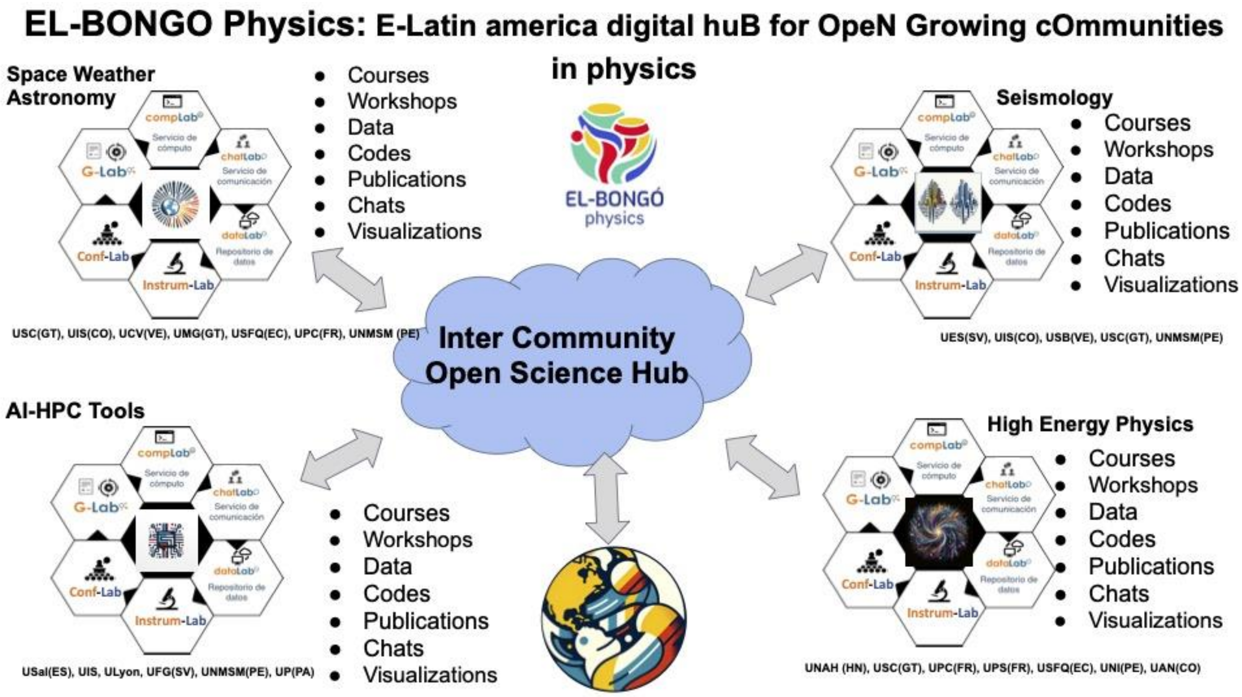
The project aims to establish a collaborative *Digital Science Gateway* for science and education, enhance research and training capacities, utilise advanced digital infrastructures, and engage global communities. The Digital Science Gateway Hub is key to overcoming geographic and socioeconomic barriers by providing access to educational resources and opportunities. It enables personalised learning experiences and supports real-time communication, networking, and collaboration among academic and research-learning communities. This digital hub also increases the visibility and dissemination of research results, expanding learning and professional development opportunities.

The EL-BONGÓ physics project work plan is structured into six work packages, each with specific objectives and activities. These work packages cover areas such as preparation, development and deployment of tools, training and education, quality assurance, dissemination and exploitation, and overall project management. Institutional responsibilities within each work package are assigned according to areas of expertise. The Universidad Antonio Nariño (Colombia) is leading as the coordinator Institution, with Université Paris Cité and Universidad Industrial de Santander

[1] A **FABLab** (Fabrication Laboratory) is a small workshop equipped with digital tools like 3D printers, laser cutters, and CNC machines that allow people to design and create almost anything. Originating from MIT, Fab Labs are part of a global network that promotes hands-on learning, innovation, and collaboration in fields like engineering, art, and education.

Funded by the European Union

serving as Co-Principal coordinators, facilitating the transfer of administrative expertise from Europe to Latin America.



Colombia:

- **Universidad Industrial de Santander (UIS)** is a public university in Bucaramanga, Colombia, with additional regional campuses. Known for its strong research focus, UIS boasts extensive facilities, including the Guatiguará Technological Park, and is recognised for its high academic output in engineering, sciences, and medicine. The Physics School at UIS is particularly renowned for its research in diverse areas like Material Science, Computational Physics, Plasma Technology, Relativity, Optics, and Atomic Spectroscopy. It actively contributes to international observatories, offering advanced programs such as a doctoral program and master's degrees in Physics, Applied Mathematics, and Geophysics. UIS also features a particular unit for supercomputing and scientific computing (SC3UIS), which supports advanced research computing needs. SC3UIS is internationally acknowledged, participating in various international projects, training schools, and collaborations across research, industry, and non-profits, including partnerships with organisations like NVIDIA and AMD.

- **Universidad Antonio Nariño (UAN),** established on March 7, 1976, is a private, non-profit institution. UAN has continuously improved its academic offerings, constructing facilities allocating laboratories, audiovisuals, libraries, and computer centres. Research at UAN is robust, particularly in physical sciences, math education, engineering, and health sciences. The university has strong research groups in these areas and has been committed to becoming a leading research institute in Colombia. Notable research activities include the Experimental High Energy Physics Research Group, created in 2006 and part of the ATLAS Collaboration at the European Organization for Nuclear Research (CERN).

- **Universidad Autónoma de Bucaramanga** (UNAB) in Colombia, established in 1952, has evolved remarkably from its initial focus on Law, Administration, and Public Accounting to encompass a broad spectrum of academic disciplines. Research at UNAB stands out, especially in Computer Science, showcasing strengths in Cyber Security, Neuroscience, Machine Learning, and AI. Its engineering program excels in areas like optical and mechanical engineering, whereas its environmental science program, which focuses on geography, ecology, and palaeontology, holds a significant position. Among its diverse faculties, the Faculty of Social Communication is a cornerstone of UNAB's academic excellence. Prestigious bodies accredit the faculty's programs and have earned distinguished awards for educational quality and journalistic excellence. This emphasis on rigorous and impactful journalism education has significantly contributed to UNAB's research strengths, especially in areas where interdisciplinary knowledge and communication skills are crucial.

Ecuador:

- **Universidad San Francisco de Quito (USFQ)** is a private liberal arts university in Quito, Ecuador. It was Ecuador's first private self-financed university and the first liberal arts institution in the Andean region. Academically, USFQ is a private liberal arts university in Quito, Ecuador. It was Ecuador's first private self-financed university and the first liberal arts institution in the Andean region. Academically, USFQ ranks as one of the three top universities (category A) in the ranking of Ecuadorian universities (being the only private university to qualify for the highest category) issued by the Ecuadorian Council of Evaluation and Accreditation of High Education (Consejo Nacional de Evaluación y Acreditación de la Educación Superior CONEA). In 2009, it was ranked first in Ecuador concerning the number of peer-reviewed scientific publications. In research, USFQ has made significant contributions in various fields. Notable achievements include involvement in the DZero experiment at Fermilab, USFQ's role in the inclusion of Ecuador as a member of the CMS Collaboration of the LHC at CERN, hosting the first and second World Summits on Evolution, extensive environmental science and biology research, and significant contributions to Ecuadorian cinema.

- **Escuela Superior Politécnica de Chimborazo (ESPOCh)** is a public university founded in 1972, is in Riobamba, Ecuador and has been part of the Ecuadorian Network of Universities for Research and Postgraduate Studies since 2012. The Physics School is part of the LAGO Observatory.

El Salvador:

- **Universidad de El Salvador (UES)**, founded on February 16, 1841, is the oldest and most prominent public university in El Salvador. Its main campus, Ciudad Universitaria, is in San Salvador, with branches in other cities such as Santa Ana, San Miguel, and San Vicente. The university encompasses nine faculties: Agronomy, Economic Sciences, Science and Humanities, Natural Sciences and Mathematics, Engineering and Architecture, Jurisprudence and Social Sciences, Medicine, Odontology, and Chemistry and Pharmacy.

- **Universidad Francisco Gavidia (UFG)** in El Salvador, established on March 7, 1981, is a private, non-profit university. Renowned for its faculties in Engineering, Systems, Economic Sciences, Arts, Design, Social Sciences, and Legal Sciences, UFG has been instrumental in advancing scientific activities through its Institute of Science, Technology, and Innovation (ICTI). The ICTI, central to UFG's digital transformation, boasts advanced equipment like a Scanning Electron Microscope and contributes significantly to scientific research.

Guatemala:

- **Universidad San Carlos de Guatemala (USAC)** is Guatemala's oldest and largest university, founded in 1676. It is also one of the oldest universities in the Americas. The university comprises 40 academic units, including ten colleges, ten schools, 19 regional centres, and one technical institute, with over 150,000 students enrolled. The Institute for Research in Physical and Mathematical Sciences at the School of Physical and Mathematical Sciences includes High Energy Physics, Cosmology and Astrophysics, Nonlinear Sciences and Complex Systems, Geophysics, Experimental Physics, and Radiation Physics. In particular, they are part of the LAGO Observatory collaboration.

Honduras:

- **Universidad Nacional Autónoma de Honduras (UNAH)**, established in 1847, is Honduras' oldest and most distinguished institution for higher education. With a constitutional mandate, UNAH plays a crucial role in organising, directing, and developing the nation's higher education and receives 6% of Honduras' GDP for support. The university is known for its extensive range of faculties and nationwide presence through regional centres. It is particularly notable for participating in significant international projects, including the LHCb experiment at CERN, emphasising its commitment to global scientific collaboration. UNAH is unique in Honduras, offering specialised Physics, Mathematics, Biology, and Microbiology programs. With about 85,000 students, it represents over 80% of the country's higher education population, making it a central figure in shaping Honduras' intellectual and academic landscape.

Perú:

- **Universidad Nacional Mayor de San Marcos (UNMSM)** in Peru, established in 1551, is a public research university in Lima and the oldest continuously operating university in the Americas. UNMSM is the best public university in Peru and has significantly contributed to scientific research in Peru, with over 6000 research works having international visibility. The university stands out for its consistent knowledge generation and is ranked fourth among 13 Peruvian universities globally for producing more than 100 works with international visibility. The university's postgraduate unit, established in 1973, offers master's and doctoral programs in physics, emphasising the training of highly specialised human resources for scientific and technological knowledge generation. The Faculty of Physical Sciences hosts 26 research groups covering diverse areas like metal physics, environmental applications of physics, thermofluids, energy engineering, soil science, and more.

Venezuela:

- **Universidad Central de Venezuela (UCV)** is one of the oldest and most prestigious universities in Venezuela and Latin America. Established in 1721, it has a long-standing tradition in various fields of study, including Physics. The university is known for its vital academic programs and research initiatives. These include theoretical physics, applied physics, materials science, astrophysics, particle physics, and condensed matter physics.

- **Universidad Simón Bolívar (USB)** in Venezuela is recognised for its strong emphasis on science and technology. Established in the late 1960s, it has developed a reputation for its rigorous academic programs and research initiatives. In Physics, USB likely engages in diverse research areas, including theoretical physics, applied physics, materials science, geophysics, optics, astrophysics and particle physics, given the university's strong focus on scientific research and technology.

Connection with LA-CoNGA physics and its legacy.

The evolution from LA-CoNGA physics to EL BONGÓ physics represents a strategic and pedagogical continuum in modernising advanced physics education across Latin America. LA-CoNGA physics laid the groundwork by upgrading educational infrastructure and implementing a one-year Bologna-style Master's curriculum in High Energy Physics and Complex Systems. It established a strong collaborative framework among eight Latin American universities and European partners; 67 students were trained and over 320 hours of coursework with contributions from 30 instructors were delivered. Its success was amplified through remote laboratory access and open seminars, fostering a robust Research and Learning Community (RLC) rooted in open science and interdisciplinary engagement. EL BONGÓ physics project launched a second capacity-building phase with an expanded regional scope and enhanced methodological ambition. EL-BONGÓ physics extends the LA-CoNGA model to Central America, integrating institutions from Guatemala, Honduras, and El Salvador, thereby addressing educational disparities and promoting regional cohesion. It introduces a do-it-yourself and learning-by-research pedagogical strategy that empowers students to design and conduct experiments using FABLab infrastructures. These FABLabs become essential nodes for innovation and knowledge creation, bridging digital learning and hands-on practice. Central to EL-BONGÓ's physics structure is the formation of thematic RLCs in four cutting-edge areas, reinforcing its interdisciplinary, socially engaged education mission. Furthermore, the project elevates the role of science diplomacy by actively engaging the Latin American scientific diaspora, leveraging their expertise to strengthen institutional capacity and international cooperation. This timeline illustrates a seamless yet transformative transition, where LA-CoNGA's foundational achievements catalyse a broader, more inclusive, and diplomatically engaged educational ecosystem under EL-BONGÓ physics.

Structure and purpose of this report.

This report includes the project's philosophy, the communities' definitions, the research lines, and the first drafts of the courses that will be developed.

This report documents the activities and outcomes of Work Package 1 (WP1) – *Preparation*, of the EL-BONGÓ physics project. It has been designed to offer a clear and comprehensive overview of the foundational work undertaken during the project's first phase, which focused on laying the groundwork for developing the research-learning communities and their training programs.

The report begins by outlining the philosophy that underpins EL-BONGÓ physics, highlighting its emphasis on open science, digital transformation, and regional collaboration across Latin America and Europe. This guiding vision shapes every aspect of the project, from its organizational structure to the pedagogical approach of its training programs.

It then presents a detailed definition of the research-learning communities, including their institutional composition, thematic focus, and organizational structure. These communities represent the core units through which the project will foster collaboration between students, educators, and researchers in physics and related disciplines.

In addition, the report includes a description of the leading research lines that have been identified in alignment with regional priorities and global scientific trends. These research areas form the intellectual backbone of the communities and guide educational content design.

Finally, the document presents the initial drafts of the training modules that will be developed and implemented during the subsequent phases of the project. These drafts include preliminary lists of learning outcomes, course prerequisites, and content outlines, serving as a basis for curriculum development and inter-institutional coordination.

Together, these elements illustrate how WP1 has contributed to ensuring the coherence, relevance, and feasibility of the EL-BONGÓ physics training program, and how it sets the stage for the successful execution of future work packages.

Objectives of the WP1

Community Development Task Force

One of WP1's primary objectives was the establishment of four collaborative Research and Learning Communities (RLCs), each bringing together students, educators, and researchers from partner institutions across Latin America and Europe. This goal was driven by the need to foster dynamic, interdisciplinary ecosystems capable of sustaining long-term collaboration and innovation in physics and related areas.

The Community Development Task Force worked to define each community's purpose and identity, ensuring alignment with institutional capacities and regional scientific priorities. The outcomes of this work include a clear articulation of each community's goals, the formulation of shared research agendas, and the identification of key actors responsible for implementation and coordination.

A governance framework was also proposed to ensure operational efficiency and sustainability. This framework outlines the procedures for managing community activities, distributing resources, and fostering inclusive participation. It supports horizontal collaboration across communities and vertical integration within institutions.

Syllabus Development Task Force

In parallel, the Syllabus Development Task Force focused on designing a training program that could be tailored to each community's context while maintaining coherence with the broader goals of the EL-BONGÓ physics project. This program builds on the LA-CoNGA physics curriculum, adapting its core principles to local needs and institutional formats.

The proposed modular structure consists of short, intensive courses of approximately 16 hours each, equivalent to 3 ECTS. These courses include core disciplinary and elective or transversal modules, allowing for flexibility and personalisation of the learning path. Importantly, differences between the European and Latin American credit systems and teaching cultures were considered during the design process, ensuring compatibility and relevance across contexts.

The task force also laid the foundation for educational activities supporting the training program, such as mentoring schemes, faculty exchanges, and joint seminars and workshops. These activities are intended to deliver content and cultivate a culture of collaborative learning and professional development within and across the RLCs.

Research and learning communities in the EL-BONGÓ physics project

As described in the design of the project, we have identified four important communities which will be the basis of the EL-BONGÓ physics project. These communities extend the reach of the previous La-CONGA project and introduce communities which can produce frontier science and can also contribute to solve important societal problems in Latin-America. These communities are: Astroparticles, High Energy physics, Geophysics, HPC and AI.

As described in the original project, the objective is to identify key players in the institutions participating in the project and create new synergies within new collaborations in the physics community as well as create collaboration between all communities to expand the capacity building and create long term relationships of collaboration and formation of new postgraduate students.

In the first months of the project, a comprehensive effort has been made to identify members of the communities, define research objectives and research activities for the communities around the EL-BONGÓ physics. Also, the communities have started meetings and spaces in collaboration tools (matter most chat rooms, GitLab sites, Indico sites, etc) to outline common infrastructures and tools as well as training strategies which will later be developed in detailed postgraduate courses and formation itineraries. In the following, we describe the summary of the work done by the different communities.

Astroparticles and multi-messengers

The Astroparticle and multi-messengers community of the EL-BONGÓ physics ERASMUS+ project aims to strengthen regional capacity in experimental and computational astroparticle physics through collaborative research, training, and accessible technology. Linked to the LAGO network, it uses Water Cherenkov Detectors and low-cost instruments for studies on cosmic rays and atmospheric phenomena. It focuses on student engagement, modular education, and inclusion, particularly at the undergraduate level. Institutions across Latin America collaborate on shared projects and open data practices, using platforms as MiLAB to support coordination. The community fosters cross-border cooperation, skill development, training and broader access to frontier science in the Global South.

Objective of the Community

The astroparticle community seeks to establish a collaborative scientific network across Latin America, oriented toward education, research, and technological development in astroparticle physics. Their goals include training talent, developing regional capacity, generating and curating open data, and creating impactful scientific and social outcomes through shared projects.

Tentative Lines of Work

The community has identified several thematic and structural lines of work:

- **Research areas**: cosmic ray detection, space weather, muography, moisture monitoring trough cosmic neutron sensing, and atmospheric phenomena using astroparticles.

- **Technical integration**: developing a shared detector network (including low-cost muon detectors like the Cosmic Watch and Water Cherenkov detectors of the LAGO collaboration) for educational and scientific use.

- **Collaborative projects** include simulation campaigns of cosmic ray flux, muon tomography, multiregional data integration, and shared analysis workflows.

- **Citizen science**: implementation of hackathons and outreach through participatory experiments.

- **Institutional collaboration**: engagement with FABLabs for instrumentation building and collaboration with other disciplinary communities such as high-energy physics and computational science.

Infrastructure and Tools

The community aims to deploy assembled and kit-form detectors to foster technical skill development and data generation capacity. The group has discussed and started deploying several detection systems:

- **Cosmic Watch**: portable muon detectors using scintillators and silicon photomultipliers for local measurements and educational purposes.
- **Water Cherenkov detectors**: aligned with the LAGO project for high-precision cosmic ray studies.
- **Geiger counters** and **neutron detectors**: for muography and environmental monitoring.

Training Strategy

The community proposes a structured modular training strategy that includes:

- **Short, focused courses** (8 hours over two weeks) on data science, instrumentation, and specific topics like muography or space weather.
- **Hands-on training** via FABLabs and practical sessions in instrumentation.
- **A two-semester s-level program**: general overview in the first semester and specialised tools (e.g., simulations) in the second.
- **Internships and intensive schools**: 2-week or 3-month research internships, supported by collaboration with projects like LAGO.
- **Flexible formats** to accommodate students from different academic calendars and backgrounds, including advanced undergraduates.
- **Inclusion of asynchronous learning and citizen science projects** to broaden participation.

Community Members

El Salvador

- Brisa Margarita Terezón Segura – Universidad Don Bosco (UDB), Director of the Micro-Macro Observatory

Colombia

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- Mario Audelo – Escuela Superior Politécnica de Chimborazo (ESPOCH)

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- José Rodrigo Sacahui Reyes – Universidad de San Carlos de Guatemala (USAC), School of Physical and Mathematical Sciences

Peru

- Teofilo Vargas Auccalla – Universidad Nacional Mayor de San Marcos (UNMSM)

Venezuela

- José Antonio López Rodríguez – Universidad Central de Venezuela (UCV)

High Energy physics

Objective of the Community

The EL-BONGÓ High Energy Physics (HEP) community promotes regional collaboration in experimental and theoretical HEP, emphasizing participation in major international experiments such as ATLAS, CMS, LHCb, and DUNE. Member countries already contribute to these efforts: Central America to LHCb, Colombia to ATLAS and DUNE, Ecuador to CMS, and Peru to MINERvA and DUNE in neutrino research. The community prioritizes joint student training, research collaboration, and capacity building through shared courses and seminars. It also supports developing expertise in detector and accelerator physics, including applications in medical physics, aiming to link research with industry. Modular training programs will provide flexible education tailored to students' research interests. The community integrates with regional networks like CONHEP, LAA-HECAP, and the Central American HEP Network to enhance cooperation and infrastructure across Latin America. These efforts aim to expand scientific capabilities and participation in global research while addressing local educational and technological needs.

Tentative Lines of Work

The community has identified the following tentative lines of work:

- **Research areas**: detector physics, neutrino physics, accelerators for Medical and High Energy Physics, Radiation protection in medical physics, quantum field theory.
- **Citizen science**: Implement science communication and outreach initiatives in schools and universities to build early interest in HEP.
- **Institutional collaboration**: Strengthen connections with established groups such as the High Energy Physics Network of Central America, the Colombian Network on High Energy Physics (CONHEP), and LAA-HECAP to share best practices, speakers, and funding opportunities.

Infrastructure and Tools

- **Shared Infrastructure and Resources**: promote the use of shared computing, simulation tools, and experimental platforms within the network, especially for institutions with limited access.
- **Particle and radiation detectors:** in alignment with the astroparticle community, these detectors provide a way to learn the basics of particle detection and signal processing concepts that are used in the muon systems of ATLAS and CMS.
- **Detectors for air quality monitoring**

Training Strategy

- **Creation of General Modular Courses**: Develop a set of core modules covering foundational topics in theoretical and experimental HEP, detector physics and accelerator physics, and their applications (including medical physics).

- **Tailored Learning Paths**: Allow students to customize their coursework based on their thesis topic and research interest, ensuring targeted and relevant training.

- **Delivery Format**: Offer courses in hybrid formats (online and in-person) to maximize accessibility for students across different regions, including those with limited infrastructure.

- **Thesis Co-Supervision**: Promote co-advising of graduate theses across institutions within the EL-BONGÓ physics network, connecting students to mentors with diverse expertise.

- **Seminars:** these sessions feature invited experts in high energy physics and medical physics, providing students with exposure to cutting-edge research, real world applications, and current challenges in both fields.

Community Members

Canada

- Dilia Portillo – Triumf

Colombia

- Gabriela Navarro – Universidad Antonio Nariño (UAN)
- Deywis Moreno – Universidad Antonio Nariño (UAN)
- Yohany Rodriguez – Universidad Antonio Nariño (UAN)
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El Salvador

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France

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- Oscar Acevedo Sanchez - Universidad Nacional Mayor de San Marcos (UNMSM)

Spain

- Camilo Ruz Méndez – Universidad de Salamanca (USAL)

Venezuela

- José Antonio Lopez – Universidad Central de Venezuela (UCV)
- Rafael Martin – Universidad Central de Venezuela (UCV)
- Deivis Errada – InPhyMa
- Jesús Dávila Pérez – InPhyMa
- Laura Aguirre – InPhyMa

Geophysics

The EL-BONGÓ Geophysics Community brings together institutions from Latin America and Europe to develop research and education in geosciences. It focuses on applied work in seismology, volcanology, and environmental geophysics. The community combines field methods with data science and high-performance computing to address regional challenges. It supports shared training, open science practices, and the joint development of tools and curricula.

Objective of the Community

The EL-BONGÓ Geophysics Community aims to establish a collaborative, interdisciplinary network across Latin America focused on research and education in geosciences. Its specific objectives include:

- Enhancing research capacity through regional and international collaboration.
- Integrating geophysics into undergraduate and graduate programs.
- Expanding access to both field-based and computational geophysical training.
- Addressing regional challenges in volcanology, seismic risk, and climate change through applied geoscientific research.

Tentative Lines of Work

The community has identified several thematic and methodological priorities:

- **Seismology and Volcanology**: Use regional seismic networks and volcano monitoring systems for scientific studies and student training.
- **Climate Change and Energy Transition**: Application of geophysical tools to assess environmental changes and support sustainable energy strategies.
- **Geophysical Survey Methods**: Implement traditional (e.g., gravimetry, electromagnetism) and advanced techniques (e.g., GNSS, InSAR, MT).
- **Data Science in Geophysics**: Incorporation of open data practices, artificial intelligence, and machine learning into geophysical research and modelling.

Infrastructure and Tools

The geophysics community requires a range of equipment to support training and research:

- **Gravimeters**: e.g., CG6 Scintrex
- **Electromagnetic Instruments**: e.g., WalkTEM ABEM
- **Magnetometers**: e.g., GEM Systems
- **Seismic Sensors**: e.g., Raspberry Shake, TerraLoc ABEM
- **GNSS Receivers and GPS Systems**: for geodetic and tectonic studies
- **MT and InSAR Tools**: for subsurface imaging and deformation monitoring
- **Basic Educational Equipment**: e.g., pendulums, sonars for introductory experiments
- **High-Performance Computing Resources**: for data processing, modelling, and inversion analysis

Training Strategy

The training framework follows a modular and adaptable model structured around the following pillars:

- **Core Areas**: Instrumentation, theoretical foundations, data science, and research internships.
- **Hybrid Learning**: Combination of online courses, asynchronous content, and in-person field schools.
- **Summer Field Schools**: Short-term intensive field training sessions focused on data collection and analysis.
- **Curricular Integration**: Embedding geophysics modules as electives or seminars in existing master's programs.

- **Collaborative Course Design**: Institutions co-develop course content, adapt materials locally, and supervise joint research.

- **Technical Capacity Building**: Training in instrumentation, data acquisition, modelling, and AI for geoscience applications.

- **Public Engagement**: Inclusion of citizen science initiatives and hackathons to increase participation and societal relevance.

Community Members

Colombia

- José David Sanabria Gómez – Universidad Industrial de Santander (UIS)
- Manuel Alberto Flórez Torres – Universidad Industrial de Santander (UIS)
- Sait Khurama-Velásquez – Universidad Industrial de Santander (UIS)

El Salvador

- Luis Castillo – Universidad de El Salvador (UES)
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Guatemala

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- Manuel Rodríguez Maradiaga – Universidad Nacional Autónoma de Honduras (UNAH)

Peru

- César Jiménez Tintaya – Universidad Nacional Mayor de San Marcos (UNMSM)

Spain

- Puy Ayarza – Universidad de Salamanca (USAL)
- Irene de Felipe Martín – Universidad de Salamanca (USAL)
- José R. Martínez Catalán – Universidad de Salamanca (USAL)
- Imma Palomeras – Universidad de Salamanca (USAL)

AI and HPC

The EL-BONGÓ High Performance Computing and Artificial Intelligence (HPC-IA) community is part of the ERASMUS+ EL-BONGÓ physics project and includes partners from seven Latin American countries. Its purpose is to support education, research, and practical applications in HPC and AI. The community collaborates closely with other EL-BONGÓ physics groups working on astroparticles, geosciences, and high-energy physics. It focuses on building shared infrastructure, offering advanced training programs, and promoting collaborative research. This initiative aims to strengthen scientific and technological capacities in the region and align with international developments in HPC and AI.

Objectives of the Community

The HPC-IA community seeks to:

- Foster a transnational network for advanced computing and AI.
- Build computing and research capacity at partner institutions.
- Facilitate interdisciplinary applications in physics, biology, climate science, and data analysis.
- Promote equitable access to shared infrastructure and resources.
- Advance Latin America's integration into global HPC and AI ecosystems.
- Stimulate regional collaboration and visibility through open science practices.

Tentative Lines of Work

The community has identified key thematic and methodological lines, including:

- Federated Learning and Edge Computing: promoting privacy-preserving and distributed machine learning frameworks.

- Bioinformatics and Medical Image Processing**: analysing biological data and medical imagery using AI tools.

- Ethics in AI: exploring fairness, accountability, and transparency in data-driven technologies.

- Continuous and Quantum Computing**: advancing algorithmic development with international partners, especially in Europe.

- Scientific Instrumentation with AI**: using AI to develop and operate sensors and hardware systems.

- Interdisciplinary Data Ecosystems**: integrating astroparticles, geophysics, and environmental monitoring datasets.

Infrastructure and Tools

To implement its goals, the community requires:

- Access to high-performance computing clusters, provided through regional platforms such as SCALAC.

- Local HPC laboratories to train students and support experiments.

- Preservation and processing of data from particle, radiation and astroparticle detectors, seismographs, and other scientific sensors shared with allied EL-BONGÓ physics communities.

- Bioinformatics software and curated datasets for biological and environmental applications.

- Platforms such as MiLAB and Mattermost to manage data, communications, and collaborative tools.

Training Strategy

The IA-HPC community's training framework comprises:

- Four modular courses:
  - Architecture of AI and High Performance Computing (HPC).
  - Federated and scalable AI models.
  - Ethical considerations in AI.
  - Deployment and validation of AI systems.

- Flexible program design: students can enrol in one or multiple modules depending on availability and interest.

- Target groups: master's and PhD students and advanced undergraduates.

- Internships and exchanges: structured for the second and third years of the EL-BONGÓ physics project (2026–2027).

- Workshops and seminars: led by international and regional experts.

- Hackathons and citizen science initiatives: to promote engagement and practical application.

- Cross-disciplinary integration: linking computational training with the needs of other scientific domains

Community Members

Colombia

- Carlos Jaime Barrios Hernández – Universidad Industrial de Santander (UIS)
- Manuel Alberto Flórez Torres – Universidad Industrial de Santander (UIS)
- Fabio Martínez – Universidad Industrial de Santander (UIS)
- Maritza Liliana Calderón Benavides – Universidad Autónoma de Bucaramanga (UNAB)
- Juan Camilo Ramírez – Universidad Antonio Nariño (UAN)

El Salvador

- Mario Rodríguez – Universidad Francisco Gavidia (UFG)
- Héctor Ponce – Universidad Francisco Gavidia (UFG)

Ecuador

- Roberto Andrade – Universidad San Francisco de Quito (USFQ)
- María Herrera – Universidad San Francisco de Quito (USFQ)

Guatemala

- Maynor Ballina – Universidad de San Carlos de Guatemala (USAC) / The Abdus Salam ICTP
- Giovanni Ramírez – Universidad de San Carlos de Guatemala (USAC)
- Jorge Balsells Universidad de San Carlos de Guatemala (USAC)

Honduras

- Jorge Sauceda – Universidad Nacional Autónoma de Honduras (UNAH)

Venezuela

- Roxana Gajardo – Universidad Central de Venezuela (UCV)
- Robinson Rivas – Universidad Central de Venezuela (UCV)

France

- Christophe Collard – Laboratoire des 2 Infinis Toulouse (L2IT), CNRS/IN2P3
- Oscar Carrillo Institut National des Sciences Appliquées de Lyon (INSA Lyon)

Spain

- Francisco José García Peñalvo – Universidad de Salamanca (USAL)
- Alfonso González Bravo – Universidad de Salamanca (USAL)
- Camilo Ruiz Méndez – Universidad de Salamanca (USAL)

Curriculum Design and Implementation

In the EL-BONGÓ physics project, the curriculum design is linked to the research activities. The philosophy of the project is to implement the Research Based Learning (RBL) which combines the introduction of graduate students to research while building their capabilities for their professional development in the academia or public and private sectors. With this perspective the EL-BONGÓ physics project adapts innovative approaches to the formation of students. This project also includes several important elements that make it a unique opportunity to build strong research communities, strengthen participating institutions, and foster long-term collaboration between Latin America and the EU, all while contributing to the training of a new generation of scientists.

In this section, we will describe what are the most important elements which will be used to design and implement the formation of the students and how the work in the communities has been used to advance these objectives.

Research Based Learning

Research-Based Learning is an educational strategy that integrates research activities into the core of the learning process, allowing students to construct knowledge through inquiry, critical analysis, and reflective thinking. Historically, there has been ongoing debate regarding how best to bridge the gap between research and teaching in higher education. By engaging students directly in the research process, RBL not only deepens their understanding and improves their knowledge retention but also cultivates lifelong learning habits and prepares them for complex real-world challenges. This set of practices is useful to create a bridge between research and learning, and provide tools to students, researchers and institutions. It can also help to share resources for investigation and teaching as well as align the incentives for researchers, students and institutions.

This paradigm has been tested in the past, and certain important conditions must be met by both researchers/tutors and their institutions. The success of RBL requires an active role of the educator, which transforms significantly from that of a traditional lecturer to a facilitator, guide, and mentor. Educators are responsible for creating a supportive climate that encourages curiosity, questioning, critical thinking, and intellectual risk-taking. They guide the inquiry process by assisting students in developing research questions, identifying and evaluating resources, navigating methodological choices, and interpreting findings. Supporting effective communication of research processes and results is key. Building a trusting relationship where students feel safe to explore ideas and receive regular, constructive feedback is essential, requiring supervisor availability, genuine interest, and ongoing interaction.

Institutions have also an important role to play in the implementation of the RBL. Key institutional responsibilities include providing adequate resources; investing in faculty through comprehensive professional development, workload management, and incentives; supporting curriculum and assessment reform aligned with RBL principles; fostering an institutional culture that values inquiry and the research-teaching nexus; and establishing quality assurance units and processes for RBL. Institutions can create an enabling ecosystem for RBL and provide long term support to develop these initiatives.

RBL is aligned to the objectives of the Erasmus+ Capacity Building in Higher Education (CBHE). The implementation of this approach can advance several key areas targeted by CBHE funding. The following table identifies the goals of the CBHE that can be advanced through RBL.

RBL Outcome/Feature	Description	Relevant Erasmus+ CBHE Priority
Enhanced Critical Thinking/Problem Solving	Development of analytical, evaluative, and solution-oriented skills.	Ensure high quality and relevant education; Innovation in higher education (problem-based teaching); Develop foundational/soft skills.
Developed Research Skills	Practical competence in research design, data handling, analysis, and interpretation.	Ensure high quality and relevant education; Innovation in higher education (active engagement with research); Strengthen research capacity (implicit).
Improved Communication	Enhanced ability to articulate complex ideas effectively (written/oral).	Ensure high quality and relevant education; Develop soft skills.

Increased Student Autonomy/Engagement	Fosters independence, self-management, motivation, and deeper learning.	Ensure high quality and relevant education (learner-centred); Innovation in higher education; Increase accessibility (empowerment).
Strengthened Research-Teaching Nexus	Integration of research processes and culture into teaching and learning.	Ensure high quality and relevant education; Innovation in higher education; Promote reforms in HEIs (modernization).
Curriculum Innovation	Drives development of new/updated courses and pedagogical approaches.	Innovation in higher education (innovative curricula/methods); Ensure high quality and relevant education.
Faculty Development Aspect	Requires/promotes development of new teaching skills and integration of roles.	Ensure high quality and relevant education (staff training); Promote reforms in HEIs (professional development).
Links to Real-World Problems/Industry	Potential for projects addressing societal needs or involving external partners.	Ensure high quality and relevant education (relevance); Active engagement with the business world; Address social and labour market needs.

The creation of these four research communities will allow us to implement this paradigm with graduate students from several participating countries. This will improve the capabilities of students, researchers, institutions and international networks.

Hands-on education and open hardware

The research lines defined during these first months in the communities will help to define specific problems to implement the RBL with the graduate students and to identify the most relevant courses that should be imparted as a complement to the formation of the students. This definition will enable the development of joint research projects through which students can gain hands-on experience and engage with communities that support their academic and professional growth.

As described in the design of the program, the concept of Open-Source Hardware (OSH) and FABLabs will be central in this program. The idea of FABLabs for science has evolved since it was introduced to produce Do-It-Yourself (DIY) scientific instruments. The use of FABLabs is now a common practice in science as it provides a versatile platform for collaboration where the hardware, control and software can be shared, personalized and improved. The FABLabs have grown in reach and sophistication using principles of open software and with the need to optimize and customize the scientific instruments.

Open Hardware and DIY practices are not merely technical approaches; they are deeply rooted in the broader philosophy of Open Science. The Open Science movement advocates for making all aspects of the research process—including methodologies, data, software, and publications—more reproducible, transparent, reusable, collaborative, and accessible to both the scientific community and society at large.

The open nature of these approaches inherently encourages collaboration. Communities of users and developers often form around OSH projects, contributing to the iterative improvement of designs, sharing modifications, and collectively solving problems. This collaborative spirit accelerates innovation and disseminates knowledge more broadly.

A primary driver for both OSH and DIY is the democratization of access to scientific tools and knowledge. By lowering costs and barriers to entry, these practices enable wider participation in science, ensuring that the benefits of research and education are more equitably distributed. This aspect aligns directly with the goals of capacity building, aiming to empower individuals and institutions globally.

The EL-BONGÓ physics project will use the FABLabs as one of the most important elements to build capacity and foster collaboration between the institutions and researchers. The commitment to openness that is behind the OSH and DIY initiatives signifies more than just a technical shift; it shows the need to educate future scientists towards more inclusive, transparent, and participatory scientific practices. This cultural dimension is crucial for the long-term success and sustainability of capacity-building efforts. When institutions adopt OSH and DIY, they are not merely acquiring low-cost equipment; they are fostering a mindset of self-reliance, local innovation, community engagement, and continuous improvement. This active, participatory approach to technology and knowledge creation is inherently more sustainable and empowering than a passive reliance on externally sourced, often proprietary, "black-box" solutions. This shift is particularly impactful in capacity-building contexts, where the goal is to build enduring local expertise and independent capabilities.

The benefits of the hands-on approach and the use of OSH and FABLabs will have an impact on the education of graduate students. A significant challenge in physics education is the abstract nature of many core concepts. OSH addresses this by allowing students to physically build, modify, and interact with the instruments they use for experiments. This hands-on engagement provides a much deeper, more intuitive understanding of how data are collected, how instruments function, and how theoretical principles manifest in the real world. As described below, the project will help to build FABLabs which will be useful for education and research. By enabling students, educators and researchers to "tinker" with, deconstruct, and reconstruct their experimental setups, OSH facilitates a more profound and intuitive grasp of physics principles. This active construction of understanding can significantly enhance engagement and improve learning outcomes.

The significantly lower cost of OSH makes advanced experimental setups and modern laboratory experiences accessible to a much wider range of educational institutions. This democratization is crucial for providing equitable learning opportunities and ensuring that students everywhere can benefit from hands-on, inquiry-based physics education. Simultaneously, the design and setup of the network of FABLabs will be useful to optimize the resources, share knowledge among the communities and establish a common set of tools and infrastructures that will be used to implement RBL and research,

The use of FABLabs and OSH is a perfect fit for the objectives of Erasmus+ CBHE. They directly empower institutions and individuals, particularly in resource-constrained environments, to develop sustainable local capacities in physics. By enabling the local design, fabrication, adaptation, and maintenance of scientific equipment and educational tools, these approaches reduce dependency on external, often costly, resources and cultivate a culture of indigenous innovation and self-sufficiency. This empowerment is fundamental to achieving the long-term goals of modernizing higher education and building resilient academic communities.

Research internships and community building

As an integral part of its Research-Based Learning (RBL) strategy, the EL-BONGÓ physics project plans to implement research visits and stays for students enrolled in the programs created by its constituent communities. These internships will provide students with opportunities to advance their own research projects while simultaneously learning the dynamics of scientific collaboration within a supportive network. The benefits of these experiences are expected to extend to the entire EL-BONGÓ network, strengthening community ties and fostering a collaborative research environment

Distributed infrastructures

Latin America confronts a series of systemic challenges in its research and development landscape. These include limited investment in research activities, inadequate funding for postgraduate grants and contracts for young scientists, a lack of robust mechanisms for disseminating scientific findings, and limited opportunities to transfer research and innovation outcomes to society. A recognized disparity in research funding, when compared to more developed regions, has tangible consequences for innovation, technological advancement, and overall socio-economic development. Despite these challenges, the region possesses a growing and talented physics community with considerable untapped potential.

The enhancement of research capabilities, particularly through the establishment and utilization of shared, distributed and open infrastructures, offers a pathway to address some of these limitations. Such infrastructures can optimize the outputs by pooling resources, granting access to advanced technologies that would be hard to obtain for individual institutions, promote cutting-edge research, and ultimately deliver substantial benefits for both scientific advancement and capacity building.

The project proposes at least three routes to promote, design and implement distributed infrastructures to improve the capabilities of the students, researchers and institutions involved.

One of them is the design and implementation of distributed networks of detectors. These ideas discussed in the Geophysics and astroparticles communities offer significant opportunities to advance scientific knowledge and directly align with the core objectives of the Erasmus+ Capacity Building in Higher Education (CBHE) program.

A distributed network of detectors, where multiple sensors are geographically spread and interconnected, can advance scientific research in several ways: These networks can enhance the observational capabilities and allow for the study of phenomena over large spatial scales or those requiring simultaneous measurements from multiple vantage points. This is crucial in fields like atmospheric physics (e.g., monitoring air quality as planned with EL-BONGÓ's physics air-quality stations), geophysics (e.g., seismic activity), or astroparticle physics (e.g., detecting cosmic rays or neutrinos from different angles). The ability to correlate data from various locations can reveal complex patterns and dynamics that a single detector might miss.

The network of detectors and the collection of the data from computing facilities in the HPC and AI communities can provide important insights. By pooling data from multiple detectors, researchers can amass larger and more diverse datasets. This enhances the statistical significance of findings, allows for the detection of rare events, and improves the precision of measurements.

The design and construction phase of a distributed detector network often drives innovation in sensor technology, data acquisition systems, high-speed networking, distributed computing, and data analysis techniques. The EL-BONGÓ physics project's inclusion of FABLabs to develop "do-it-yourself digital fabrication skills for building scientific instruments" directly supports this aspect.

These projects will motivate collaboration and opportunities for students. These projects are collaborative by design, involving multiple institutions and research groups. The sharing of data, software tools, and expertise is inherent in their operation, aligning with Open Science principles. This allows a broader scientific community to engage with the data, fostering reproducibility and accelerating discovery. EL-BONGÓ's physics planned "Open Science Collaborative Hub" will be an essential tool for this.

The MiLAB platform and the planned Digital Science Gateway within the EL-BONGÓ physics project are designed to be central elements in advancing the concept of distributed research infrastructures. The MiLAB offers a comprehensive set of digital tools to collaborate and to implement the RBL for students. These platforms act as virtual hubs, providing researchers and students across different geographical locations with unified access to shared data, software tools, remote laboratories, and computational resources. These tools will be essential to build these distributed scientific infrastructures such as the network of detectors previously described. EL-BONGÓ physics aims to foster hands-on experience for students, using MiLAB, distributed groups of researchers and students will be able to collaborate using shared instruments, data and resources.

The project will promote collaboration between the participating communities. The HPC and AI community will be key to all of them as it will contribute to enhance their capabilities through collaboration. Distributed infrastructures, such as networks of detectors or shared experimental facilities, often generate vast amounts of data. HPC resources are essential for storing, processing, and analysing these large datasets efficiently. AI and Machine Learning (ML) techniques, which are part of EL-BONGÓ's physics training, are increasingly needed for extracting meaningful insights from complex, high-dimensional data produced by distributed systems. The collaboration with the HPC and AI community will make this possible.

Theoretical research in the communities will benefit with collaboration and access to HPC for numerical simulations. HPC access will allow researchers from our communities to perform complex simulations to support, complement and guide experiments conducted on distributed physical infrastructure.

The design of research communities to implement RBL and distributed infrastructures will be supported in EL-BONGÓ's physics with platforms like MiLAB and a Digital Science Gateway to provide the collaborative environment and access mechanisms necessary for distributed infrastructures to function effectively. The collaboration with HPC and AI communities provides the computational power and analytical capabilities required to process the data generated by these infrastructures and to extract scientific knowledge. Together, these elements create a more powerful, accessible, and efficient ecosystem for distributed research, enabling scientists to tackle more complex problems and accelerate discovery.

Curriculum design plans

The work carried out in the few months in the communities have helped to define the training strategies for each of them. As described above the main strategy will be the Research Based Learning (RBL) but the educational programs will include courses designed with the Bologna model which is the central part of the Common European Education Space (EEA). Here we describe some important issues which have been identified by the communities.

- The need for flexible learning itineraries.

Given the socio-economic realities faced by many graduate students—such as the need to work or fulfil family obligations—there is a clear demand for flexible course structures. This includes offering part-time study options, asynchronous online modules, and modular pathways that allow students to progress at their own pace without compromising academic rigor.

- The need for short courses on frontiers physics topics

To foster scientific excellence and innovation, communities have expressed a strong interest in developing short, intensive courses on cutting-edge topics in physics. These courses would not only enhance students' exposure to emerging areas but also promote connections with ongoing international research efforts.

- The need to implement to provide access to complementary topics between communities

One of the strengths of the EL-BONGÓ's physics network lies in the diversity of expertise across communities. There is a recognized need to implement mechanisms for shared access to courses and materials, allowing students to benefit from specialized knowledge and infrastructure available in partner institutions. Virtual mobility and co-taught courses could play a significant role in this.

- The need to address relevant regional issues related to the scientific communities

Curriculum planning must also be responsive to local and regional challenges. This includes integrating content that reflects regional scientific priorities—such as climate change, seismic hazards, volcanic research for risk management, etc—into research projects and thematic modules. Encouraging community-engaged research and applied science is also seen as essential.

The Bologna model for the design of master courses

The design of the courses is based on the Bologna philosophy which is the basis of the Common European Education Space (EEA) to produce a modular master's syllabus. The adoption of the Bologna philosophy for the development of master's programs for students from Latin America represents a strategic approach to create capabilities with postgraduate students in the region. Within the framework of the EL-BONGÓ physics project, the Bologna model serves as both a pedagogical foundation and an operational structure to support the creation of flexible, internationally recognized, and competence-based academic programs.

One of the principal advantages of using the Bologna model lies in its international recognition and alignment with global educational standards. By structuring the master's program according to the European Credit Transfer and Accumulation System (ECTS) and clearly defined learning outcomes, the program ensures mobility and academic equivalence, thereby increasing the potential for Latin American students to access further education or professional opportunities in Europe and other regions.

The modular design inherent to Bologna-style curricula provides essential flexibility for students in Latin America, where economic and social realities often require balancing academic studies with employment or family responsibilities. The implementation of short, self-contained modules that can be accumulated toward full degrees or used as standalone certifications allows for personalized learning pathways and greater inclusion.

Furthermore, the Bologna framework's emphasis on competency development, research orientation, and interdisciplinarity aligns closely with the objectives of the EL-BONGÓ physics project. The structure supports the formation of Research and Learning Communities (RLCs) where students are not only recipients of knowledge but active contributors to ongoing scientific projects. This "learning-by-doing-research" approach fosters the development of critical thinking, collaboration, and practical skills that are directly applicable to the scientific and technological challenges of the region.

The Bologna philosophy also enhances institutional capacity building in Latin America. By adopting this framework, partner universities modernize their postgraduate offerings, implement robust quality assurance mechanisms, and position themselves within a broader international academic network. This contributes to the long-term goal of harmonizing higher education systems and promoting regional integration.

FABLabs

EL-BONGÓ physics is not merely an extension of LA-CoNGA but a strategic reinvention—deepening the pedagogical scope, expanding institutional inclusion, and embedding research, fabrication, and diplomacy into the heart of capacity building in Latin American physics education. A core pillar of the EL-BONGÓ physics methodology is the emphasis on Do-It-Yourself experimentation, which empowers students to understand scientific instruments theoretically and engage directly in their design, construction, and application. This approach is operationalised through the creation and interconnection of FABLabs across participating institutions. The FABLab initiative is critical to the structural transformation of physics education in Latin America. It aligns with EL-BONGÓ's physics goals of democratising scientific knowledge, strengthening institutional autonomy, and building an open, collaborative ecosystem where innovation and education are mutually reinforcing. By embedding fabrication capabilities within RLCS, the project ensures that experimentation becomes not a privilege but a foundational and accessible component of physics training.

FABLabs serve as physical anchors of the Research Learning Communities. These spaces provide the technical infrastructure and digital fabrication tools—such as 3D printers, CNC machines, soldering stations, and microcontroller platforms—that enable students to prototype, assemble, and calibrate scientific and geophysical equipment. By engaging in DIY experimentation, students:

- Acquire hands-on skills in electronics, mechanics, and instrumentation.
- Integrate theoretical physics knowledge with practical application.
- Foster creativity, problem-solving, and iterative design thinking.
- Collaborate in interdisciplinary teams on real-world technical challenges.

This experiential learning process aligns with the project's broader research-based educational model, replacing passive learning with active knowledge construction.

The distributed FABLab network is designed to reduce the inequities in access to experimental resources common in underfunded or peripheral institutions. By decentralising manufacturing capabilities:

- Each partner institution can independently build, maintain, and repair scientific instruments, reducing dependency on external suppliers.
- Local adaptation and contextualisation of equipment become feasible, especially for region-specific challenges such as seismological monitoring, environmental sensing, or space weather instrumentation.
- A culture of technical autonomy and sustainability is cultivated within each RLC.

Notably, the availability of locally built equipment—such as low-cost gravimeters, seismometers, or GNSS receivers—will make experimental training scalable and inclusive, especially for students in remote or economically disadvantaged regions.

The project envisions the FABLabs not as isolated entities, but as a coordinated, transnational network. This network:

- Facilitates sharing technical designs, fabrication protocols, and user manuals under open-source licenses.
- Supports collaborative development of new instruments and kits across institutions.
- Enables peer-to-peer training in fabrication techniques, maintenance, and digital toolchains.
- Strengthens the regional ecosystem for educational technology and scientific instrumentation.

EL-BONGÓ physics develops a self-sustaining model of technological innovation and repair capacity through this collaborative infrastructure in Latin American higher education. It enhances the resilience and scalability of research training by ensuring that technical barriers do not limit educational opportunities.

To ensure that students fully integrate the competencies offered by the FABLabs, the course on Scientific Instrumentation within the EL-BONGÓ's physics Master's curriculum will incorporate a structured, hands-on module dedicated to instrument design, prototyping, and calibration using FABLab resources. This module will guide students through the complete cycle of scientific equipment development—from conceptual design and electronic schematics to fabrication, testing, and field deployment. By embedding FABLab-based projects within the coursework, students will develop practical skills in microcontroller programming, signal acquisition, sensor integration, and system troubleshooting. These experiences will be directly tied to real-world research needs, ensuring that students understand how instruments work and gain the capacity to innovate, adapt, and repair devices in diverse scientific contexts. This integration transforms the Scientific Instrumentation course into a practice-based learning environment that bridges theory with application, significantly enhancing the program's educational and technical outcomes.

Next steps and outlook

- Upcoming milestones and deliverables for WP1.

The next milestones for WP1 will focus on finalizing the structure of the master's courses based on the modular curriculum defined by each community. This includes aligning course content with the Bologna model, specifying learning outcomes, and developing teaching materials and evaluation frameworks. A key deliverable will be the preparation of a roadmap for implementation in the next academic cycle, including a schedule for course rollout, faculty assignments, and integration with digital platforms like MiLAB and the Digital Science Gateway.

- Planned activities in community building and training.

Following the initial phase of participant identification and training needs assessment, each Research and Learning Community will move into the implementation stage. This includes launching collaborative research activities, preparing course delivery logistics, and organizing mobility programs, internships, and intensive schools. Communities will also coordinate mentorship structures, set up shared infrastructure, and begin recruiting students for the first training cohorts, ensuring readiness for course delivery in the upcoming academic year.

- Coordination with other WPs.

This WP1 report will serve as a reference for other work packages by consolidating the progress made in curriculum design and community organization. It will guide WP2 in the deployment of technical platforms, inform WP3 on training content and formats, and support WP4 in the definition of quality indicators. Additionally, it will provide WP5 and WP6 with material for communication, dissemination, and project monitoring, ensuring a coherent and integrated progression across the EL-BONGÓ physics initiative.

- Expansion plans or inclusion of new participants

WP1 will also explore pathways to expand the network by inviting new institutions, researchers, and students. This may include opening participation to universities beyond the current consortium, promoting collaborations with Latin-Americans scientific diaspora, and offering external access to select training modules. These actions aim to strengthen the regional reach of the project and create open communities.

- Define quality assessment and controls of the formation plans

To ensure the effectiveness and sustainability of the training programs, WP1 will collaborate with WP4 to define a comprehensive quality assurance framework. This will include the development of course evaluation criteria, mechanisms for continuous feedback from students and instructors, and alignment with national and international accreditation standards. Key indicators such as student performance, participation rates, research outputs, and inter-institutional collaboration will be monitored to guide ongoing improvement and ensure the long-term impact of the formation plans.

International relations offices networks

The establishment of the International Relations Community within the framework of the EL-BONGÓ physics Erasmus+ Capacity Building project is a strategic initiative aimed at fostering sustainable collaboration among 17 universities from Latin America and Europe. In cross-continental cooperation projects, the international relations offices play a critical role in ensuring institutional alignment, facilitating mobility, supporting project implementation, and promoting long-term impact beyond the life of the project.

This community is justified by the need to strengthen the institutional capacities of international offices, which are often uneven across regions, and to ensure that knowledge exchange and collaboration mechanisms are not limited to academic or research units alone. By creating a dedicated space for peer learning, coordination, and co-design of internationalization strategies, the community enhances the project's relevance, ownership, and sustainability.

Moreover, it provides a practical platform to address the most common challenges—such as mobility management, funding access, curriculum internationalization, and intercultural competencies—through thematic working groups led by institutions with recognized experience in those areas. In doing so, the community not only supports capacity building but also builds the foundation for future joint projects with measurable impact across South America, Central America, and Europe.

General Objective

- To build a collaborative network for learning and joint work that strengthens the capacities of international relations offices and enables the development of international cooperation projects with impact in South America, Central America, and Europe.

Members

The International Relations Community of the EL-BONGÓ physics Project is made up of the international relations offices of the 17 higher education institutions that are part of the consortium. Each institution has appointed an official representative to actively participate in the activities, meetings, and working groups of this community.

While the core members of the community are the universities that form the EL-BONGÓ physics project consortium, universities from other countries are welcome to attend and participate in the various open activities organized throughout the implementation of the initiative. This inclusive approach seeks to expand the impact of the community and enrich the exchange of perspectives and practices

Responsibilities

- General Coordination: Alejandra Cruz (UAN - Universidad Antonio Nariño)

- Working Group Leadership: Each thematic group has a rotating coordinator designated by its members, responsible for facilitating meetings, promoting progress on common goals, and reporting back to the general coordination.

Research and collaborative work topics

The thematic groups of this community were designed through a dual approach: first, by analysing current global trends in higher education internationalization, and second, by surveying the 17 consortium universities to identify both their institutional strengths and the areas in which they aim to build capacity. This process allowed for the creation of thematic groups that align with international agendas while being grounded in the specific contexts and priorities of the participating institutions. Each group is intended to serve as a collaborative space for peer-to-peer learning and exchange of experiences. It is expected that institutions with strengths in each theme will take a leading role within that group, guiding collective work and contributing to capacity building across the network.

- **Group 1: Curriculum Internationalization and Internationalization at Home**

  Topics: COIL, mirror classrooms, curriculum integration, faculty training, dual degree programs.

Objectives:

- Promote the adoption of internationalization at home strategies that provide global learning opportunities without requiring physical mobility.
- Facilitate the design and implementation of COIL projects and mirror classroom initiatives.
- Encourage the creation and management of dual degree programs and other collaborative academic structures.
- Strengthen faculty capacity to embed internationalization into teaching and learning practices.

Expected institutional capacities:

- Capability to design and implement COIL and virtual exchange formats.
- Strengthened curriculum design processes incorporating international perspectives.
- Institutional procedures and agreements for managing joint or double degree programs.
- A teaching staff trained in the pedagogical and intercultural aspects of internationalized education.
- Broader access to international learning opportunities for students who may not participate in physical mobility programs.

- **Group 2: Capacity Building and Professional Development**

  Topics: institutional internationalization strategies, academic and scientific diplomacy training, global competencies and languages, internal internationalization policies.

Objectives:

- Support institutions in formulating and implementing comprehensive internationalization strategies.

- Promote the development of intercultural, linguistic, and global competencies among academic and administrative staff.

- Strengthen institutional structures and internal governance for internationalization.

- Provide training in academic and scientific diplomacy to enhance global engagement.

Expected institutional capacities:

- Greater institutional coherence in internationalization planning and execution.

- A skilled and globally competent staff capable of driving international initiatives.

- Clear and effective internal policies aligned with global standards.

- Enhanced institutional readiness to engage in academic diplomacy and multilateral partnerships.

Group 3: Technology, Communication, and International Visibility

Topics: digital platforms for international collaboration, institutional communication for internationalization, ICT tools for network management, global positioning and visibility.

Objectives:

- Enhance the use of digital tools and platforms to support international cooperation.

- Strengthen strategic communication for promoting internationalization initiatives.

- Improve institutional visibility and positioning in global academic networks.

- Foster innovation in the digital management of international partnerships and mobility.

Expected institutional capacities:

- Effective use of ICT for collaboration, communication, and project management.
- Stronger international branding and digital presence.
- Improved engagement with global academic and cooperation networks.
- Institutional culture that embraces digital transformation in internationalization.

- **Group 4: Funding and International Cooperation Projects**

  Topics: funding identification, project formulation, sustainability and inclusion in cooperation.

  Leader: Angela Moca of the Universidad de Toulouse

  Objectives:

  - Support institutions in identifying funding opportunities for international initiatives.
  - Strengthen capacities in project design, proposal writing, and grant management.
  - Promote inclusive and sustainable practices in international cooperation.

  Expected institutional capacities:

  - Improved access to international funding sources (e.g., Erasmus+, Horizon Europe).
  - Enhanced ability to design and implement successful cooperation projects.
  - Institutional frameworks that support sustainable and inclusive project implementation.

Training Program 2025–2027

The community will implement a continuous and collaborative training program aimed at:

- Strengthening the technical, strategic, and operational capacities of international relations offices.

- Promoting a culture of institutional internationalization based on inclusion, quality, equity, and sustainability.
- Creating spaces for knowledge exchange and co-creation among consortium members.
- Fostering inter-institutional collaboration through joint projects.

Working Methodology:

- Collaborative learning community approach.
- Active participation through self-managed thematic groups.
- Use of virtual platforms for synchronous and asynchronous meetings.
- Systematization of good practices and lessons learned.
- Combination of technical training (workshops) and strategic dialogue (seminars, roundtables).

Key Activities of the Program:

- Thematic virtual workshops (bimonthly)
- Online discussion forums by thematic group
- Webinars for experience sharing between universities
- Micro-courses on digital tools, project management, and internationalization
- Documentation and dissemination of good practices in a shared repository
- Staff Week in Colombia
  As the closing event of the training cycle and to support future initiatives, a Staff Week will be held in-person in Colombia in September 2027. This event will bring together community members to:
    - ➔ Evaluate the achievements of the thematic groups.
    - ➔ Consolidate a stable collaboration network for future international initiatives.
    - ➔ Co-design a new multilateral international cooperation project.

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➔ Strengthen ties between technical, academic, and administrative teams from participating institutions.

Appendix 1 Syllabus examples from High Energy physics

Proposed Modular Courses in the High-Energy Physics Community

As part of the research and learning community (RLC) approach promoted by the EL-BONGÓ physics project, a training offer is proposed based on modular courses aimed at graduate students and researchers in the field of High-Energy Physics. These courses follow the European Higher Education Area model (Bologna philosophy), facilitating personalized learning and encouraging the participation of a broad audience from different scientific and technological backgrounds.

The courses are structured as independent 10-hour modules (5 sessions of 2 hours each), with a strong emphasis on practical training, interdisciplinarity, and applicability in both fundamental research and industrial, medical, or technological contexts. The following tables present the proposed curriculum structure, divided by thematic course.

1. Particle Accelerators Course

Module	Title	Main Topics
1	Introduction to Particle Accelerators	History, classification, linear vs. circular accelerators, applications
2	Fundamentals of Beam Physics	Particle dynamics, beam optics and transport, phase space
3	Accelerator Technologies for Industry	Synchrotrons, cyclotrons, electron beam applications, ion implantation
4	Principles of Dielectric Laser Accelerators (DLA)	Dielectric materials, photonic structures, laser-based mechanisms

5	Design and Fabrication of DLAs	Nanofabrication, laser coupling, beam diagnostics
6	Compact Accelerators for Industry and Healthcare	Mini-linacs, FLASH therapy, high-brightness X-rays, security scanners
7	Radiation Generation and Detection	X-ray/gamma production, industrial imaging, radiation shielding
8	Computational Modelling and AI	GEANT4, beam optimization with AI, machine learning for diagnostics
9	Advanced Accelerator Concepts	Wakefield acceleration, laser-driven ions, future trends
10	Emerging Markets for Accelerators	Biotech/pharma, nuclear waste treatment, compact accelerator markets
11	Laboratory Accelerators and Simulation	Experimental configurations, beam diagnostics, modelling tools

2. Radiation Transport and Applications Course

Selected modules (overview by topic; full list available in annex):

Area	Covered Topics
Fundamentals	Radiation-matter interactions, Monte Carlo methods, shielding
Radiobiology	Cellular responses, genetic sensitivity, microRNAs
Medical Physics	Imaging, radiotherapy, clinical simulations
High-Energy Labs	Beam interactions, shielding strategies, electronics under radiation

Space Applications	Cosmic rays, spacecraft protection, testing standards
Simulation and Computing	Advanced Monte Carlo, AI, validation of results

3. Nuclear Physics Course

Module	Focus
1–3	Nuclear interactions, nuclear models, experimental techniques
4–6	Fission and fusion, nuclear energy, medical applications
7–9	Cosmic nucleosynthesis, neutron stars, heavy-ion collisions
10–12	Space exploration, simulation tools, nuclear energy policy in Latin America

4. Hadron and High-Energy Radiotherapy Course

Module	Content
1–3	Radiation physics, high-energy beam properties, hadron therapy basics
4–6	Radiobiology, clinical implementation, complex tumor treatments
7–9	Medical accelerators, Monte Carlo simulations, treatment planning
10–12	Radiation protection, future technologies (FLASH, PMBRT), engineering and access challenges

Appendix 2: Account of the meetings in each community

- Overview of meetings, workshops, or community engagement activities. (Appendix)

Date	**Research Community**	**Topics Discussed**	
March 17	2025	Astroparticles and multi-messengers	1. Launch of the EL-BONGÓ physics project and introduction of the astroparticle research community. 2. Proposal for a cosmic ray detector network and muography-based studies. 3. Planning for low-cost detector fabrication and international research collaboration. 4. Initial coordination to share institutional interests and prepare joint field projects.
April 7	2025	Astroparticles and multi-messengers	1. Community-building strategies for astroparticle physics in Latin America and Africa. 2. Introduction of the Cosmic Watch device and its research and educational uses. 3. Development of a global radiation monitoring network. 4. Creation of a synthesis document and collaborative channel for ongoing contributions.
April 21	2025	Astroparticles and multi-messengers	1. Training plan in data science, instrumentation, and astroparticles. 2. Design of a master's program with modular content and practical components. 3. Coordination to avoid overlap and align with academic calendars. 4. Strategies for student recruitment and integration with other communities.

March 25	2025	Geophysics	1. Presentation of the EL-BONGÓ geophysics and seismology initiative. 2. Setup of digital fabrication labs for geophysical sensors. 3. Planning collaborative education and mobility across Latin America. 4. Proposal for training workshops and data-sharing infrastructure.
April 8	2025	Geophysics	1. Expansion from seismology to geophysics including geodesy and prospection. 2. Setup of a Mattermost collaboration platform. 3. Planning of low-cost lab equipment and regional summer schools. 4. Budget planning for Fab Labs and mobility funding.
April 22	2025	Geophysics	1. Planning of regional geoscience programs including volcanology and climate change. 2. Curriculum integration with institutional programs. 3. Infrastructure for data analysis and student research groups. 4. Drafting of a collaborative academic article on learning communities.
April 29	2025	Geophysics	1. Reform of master's curriculum to include field schools and modular learning. 2. Assessment of available geophysical equipment by country. 3. Proposal for mixed undergraduate/graduate courses. 4. Update of course content including GIS and inversion techniques.

March 3	2025	High Energy Physics	1. What are and what is the importance of the education and research communities for the project EL-BONGÓ physics? Presentation by Camilo Ruiz 2. How do we build the high energy physics community?. Presentation by Gabriela Navarro.
April 3	2025	High Energy Physics	1. Formation of HEP research groups in Latin America and CERN collaborations. 2. Modular education model adapted from LA-CoNGA. 3. Addressing challenges in asynchronous learning and digital resource usage. 4. Drafting a report and creating a Latin American HEP network.
April 10	2025	High Energy Physics	1. Structure of a master's program with focus on medical physics, detectors, and nuclear physics. 2. Alignment of student research with active projects. 3. Modular curriculum inspired by major/minor systems. 4. Planning of a laser-focused Erasmus+ proposal for regional training.
April 24	2025	High Energy Physics	1. Design of modular courses and inclusion of interdisciplinary experts. 2. Integration of Fab Lab-built detectors for practical training. 3. Use of CMOS sensors and low-cost dosimetry tools. 4. Collaboration with AI and CERN-based data formats.

March 26	2025	AI & High-Performance Computing	1. Launch of the EL-BONGÓ AI/HPC community focusing on high energy physics, machine learning, and distributed computing. 2. Introduction of institutional capabilities and collaborative research opportunities across Latin America. 3. Proposal for a shared computational platform and use of SCALAC and Grid 5000 resources. 4. Planning of student mobility and internships in institutions across Europe and Latin America. 5. Integration of AI in sensor workflows and federated computing models. 6. Development of modular courses and collaboration tools for the AI/HPC community.
April 9	2025	AI & High Performance Computing	1. Coordination of a Latin American AI/HPC research community within the EL-BONGÓ physics project. 2. Identification of research lines and infrastructure needs by participating institutions. 3. Presentation of bioinformatics work and interest in applying AI to environmental DNA analysis. 4. Needs for advanced computing access in doctoral research on AI, image processing, and modeling. 5. Plans for federated learning projects and leveraging ESCALAC infrastructure. 6. Proposal to co-develop courses on AI, HPC, and interdisciplinary applications.
April 23	2025	AI & High Performance Computing	1. Overview of SCALAC collaboration and its support for advanced computing in Latin America and the Caribbean. 2. Presentation of SCALAC's institutional alliances, activities, and its role in promoting regional HPC and AI capacity.

			3. Discussion of support mechanisms for EL-BONGÓ physics, including user guidance and remote resource access. 4. Proposal to formalize collaboration via a memorandum of understanding between SCALAC and EL-BONGÓ physics. 5. Plans for joint development of training programs, workshops, and schools across partner countries.
April 30	2025	AI & High-Performance Computing	1. Establishment of a regional learning community in HPC and AI focused on student training and cross-country collaboration. 2. Development of four modular AI courses including models, federated systems, architecture, and ethical implications. 3. Proposal for collaborative research projects in federated AI, continuous computing, and AI ethics. 4. Flexible program structure allowing students to choose courses based on interest and institutional offerings. 5. Agreement to define course content, coordinate project sharing, and expand the network across the region.