EURO-LABS: INTEGRATING EUROPEAN RESEARCH INFRASTRUCTURES FOR PHYSICAL SCIENCES*

I. Efthymiopoulos†, CERN, Geneva, Switzerland; M. Colonna, P. Giacomelli, INFN, Italy;
M.J. Garcia Borje, CIEMAT, Spain; A. Maj, IFJ-PAN, Poland;
M. Mikuz, JSI, Slovenia; A. Navin, GANIL, France

Abstract

The European Laboratories for Accelerator Based Sciences (EURO-LABS) advances research frontiers by providing unified **Transnational Access (TNA)** to leading European Research Infrastructures (RIs) in the Physical Sciences. It brings together the nuclear physics, accelerator, and HEP detector R&D communities to foster collaboration and stimulate synergies. With 33 partners across Europe, EURO-LABS forms an integrated network of RIs ranging from small-scale test facilities to large European Strategy Forum on Research Infrastructures (ESFRI). The access provided enables research at the technological frontiers of accelerator and detector development, supporting the exploration of new physics concepts and opening new avenues in both fundamental and applied research — from optimizing reactor operation to mimicking stellar reactions. EURO-LABS actively promotes diversity and inclusion, offering broad and open access to researchers across nationalities, genders, ages, and career stages, while strengthening Europe's collaborative scientific landscape.

This contribution gives an overview of the project structure, the participating research infrastructures and access activities, together with highlights of the outcomes.

INTRODUCTION

EURO-LABS [1] is a pioneering European project aimed at building synergies and collaborations between the Research Infrastructures (RIs) of the Nuclear Physics (NP) and High-Energy Physics (HEP) communities. The project was established in response to a challenge of the Horizon Europe Programme [2], to bring together communities in the Physical Sciences domain, with the objective of providing wider, simplified, and more efficient access to leading research infrastructures across Europe. By offering transnational access free of charge, EURO-LABS enables researchers to conduct curiosity-driven research independently of their geographical location.

A central goal of the programme is to support breakthrough and frontier research by making advanced RI services available for access to a broader scientific community. For the first time, the Nuclear Physics and High-Energy Physics RI communities are brought together within a common framework, promoting harmonised services and a more efficient use of resources through the exploitation of complementarities and synergies. Additional objectives include fostering cross-disciplinary collaborations, enhancing the exchange of knowledge and technologies, and training a new generation of researchers to fully exploit advanced research infrastructures and equipment. The project also addresses the efficient management of transnational access procedures, including the implementation of FAIR data principles for the large volumes of data produced by the participating facilities.

RIS LANDSCAPE

EURO-LABS started in September 2022 and will run until August 2026. It brings together 33 partner institutions from 18 European and non-European countries, involving 45 leading RI facilities (Fig. 1).

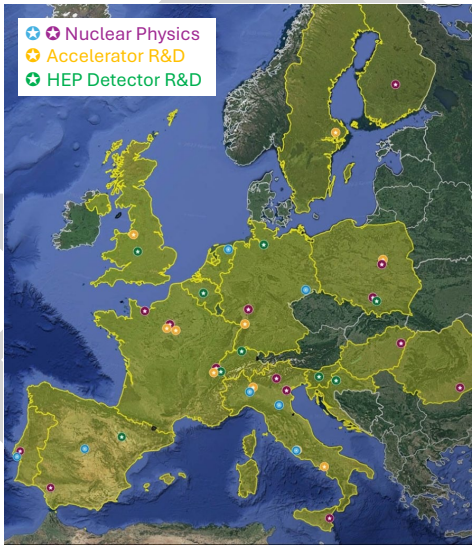

Figure 1: Map of EURO-LABS partner institutions and participating RIs across Europe. Associated-partner facilities in the US and Japan, are not shown here.

Nuclear Physics RIs

The Nuclear Physics RIs within EURO-LABS provide European and international users with TNA access to world-leading facilities delivering high-intensity stable ion beams, in some cases reaching the pμA range, covering isotopes from hydrogen to uranium. The broad EURO-LABS portofolio extends to facilities producing high-energy radioactive ion beams, nuclei not existing on Earth, using in-flight fragmentation techniques (of nano-sec lifetime). Post-accelerated radioactive ion beams (of msec half-time) using ISOL (Isotope Separation On-Line) methods offered for TNA access, as well as to neutron-beam facilities.

For the first time, EURO-LABS also introduced a **Virtual Access (VA)** scheme offering access to the European Centre

* EU Grant Agreement No 101057511
† Ilias.Efthymiopoulos@cern.ch

for Theoretical Studies in Nuclear Physics and Related Areas, and to theoretical support for experiments. Table 1 summarizes the participating TNA and VA facilities. The scientific goal of the NP Transnational Access is to provide enhanced opportunities for exploring nuclei under extreme conditions: at high temperature (T), high angular momentum (L), large isospin (N/Z), and extreme masses (A), including nuclei close to the proton and neutron driplines. The supported TNA projects focus on addressing key open questions in the field, including among others the emergence of nuclear structure from nucleon interactions and the limits of nuclear stability and production of new chemical elements. The programme also supports innovative applications, including developments related to ion-beam cancer therapy.

Table 1: Participating Facilities in Nuclear Physics. ESFRI roadmap RIs are shown in bold

Type	Country	Host Lab	Infrastructure
S,R,N	Italy	INFN	LNL-NSDBF; LNS-AIPF
S,R,N	France	GANIL	**SPIRAL2**
S,R,N	France	CNRS-IJCLab	ALTO
S,R	Germany	GSI	**FAIR**
S,R	Finland	Univ. Jyvaskula	JYFL
R	Switzerland	CERN	ISOLDE
N	Switzerland	CERN	nTOF
S	Poland	Univ. Warsaw	NLC-SLCJ
S	Poland	IFJPAN	NLC-CCB
S	Romania	IFIN-HH	Tandem
S,N	Spain	USE	CLEAR
S,N	Hungary	ATOMKI	CLEAR
S,N	Portugal	IST	CLEAR
Theory	Italy	ECT	ECT
Theory/VA	Poland	IFJPAN	Meanfield4Exp
Theory/VA	Spain	USE	Reaction4Exp
Theory/VA	Italy	U.Milano	Structure4Expt

S = Stable ion beams, R = Radioactive ion beams, N = Neutron beams.

Accelerator R&D RIs

This activity provides TNA to a broad range of unique and specialized accelerator R&D facilities supporting the development and validation of concepts for future accelerator infrastructures, including studies relevant for next-generation colliders such as the CERN Future Circular Collider (FCC) and the Muon Collider. The participating facilities enable experimental investigations of advanced accelerator technologies, including superconducting and normal-conducting radio-frequency cavities, magnets, novel accelerator materials, and advanced acceleration schemes. Table 2 summarizes the portfolio of participating facilities.

HEP Detector R&D RIs

The RIs included in this area provide TNA access to a broad range of facilities delivering energetic particle beams (protons, mesons, muons, and electrons), as well as irradiation facilities operating with mixed hadron and γ fields. These facilities, summarized in Table 3, support detector prototype testing and characterisation studies. Such measurements are essential for understanding the behaviour and radiation tolerance of detectors and associated instrumentation under realistic beam conditions, supporting detector upgrades for HL-LHC operation and the development of future detector technologies.

Table 2: Participating facilities in Accelerator R&D. ESFRI roadmap RIs are shown in bold

Type	Country	Host Lab	Infrastructure
MT	Switzerland	CERN	HiRadMat
TI	Sweden	Univ. Uppsala	FREIA
TI	Italy	INFN-MI	LASA
TI	Italy	INFN-Univ. Sal	THOR
TI	France	CNRS-JCLab	SUPRATECH
TI	France	CEA Irfu-Synergium	MACHAFILM; CRYOMECH
TI	Switzerland	CERN	XBOX
EP	Germany	KIT-ALFA	KARA; FLUTE
EP	UK	STFC	CLARA, VELA
EP	Italy	INFN-Frascati	BTF; **SPARClab**
EP	France	CEA LiDyL	LPA-UHI100
APP	Poland	INTC	RAPID
APP	Switzerland	CERN	CLEAR

MT = Material Testing, TI = Technology Infrastructure, EP = Electron & Plasma Beam, APP = Applications.

Table 3: Participating Facilities in HEP Detector R&D.ESFRI roadmap RIs are shown in bold

Type	Country	Host Lab	Infrastructure
TB	Switzerland	CERN	**PS** & **SPS**
TB	Germany	DESY	DESY-II
DC	Croatia	RBI	RBI-AF
DC	Spain	ITAINNOVA	EMCLab
DC	Switzerland	CERN	IRRAD; GIF++
DC	Slovenia	JSI	TRIGA Reactor
DC	Poland	IFJPAN	AIC-144
DC	Belgium	UCLouvain	CRC
DC	UK	UoB	MC40 Cyclotron

TB = Test Beams, DC = Detector Characterization.

Beyond the Transnational Access programme, EURO-LABS also supported targeted service improvements at several participating facilities, aimed at enhancing the available performance, operational capabilities, and parameter range of the RIs for the benefit of the user community. These activities included the development of novel beam-control approaches based on **machine-learning (ML)** techniques to improve beam quality, transport efficiency, and operational reproducibility [3].

In Nuclear Physics, significant effort was additionally devoted to integrating community data and services within the European Open Science Cloud (EOSC) framework, with the objective of strengthening the implementation of FAIR (Findable, Accessible, Interoperable, and Reusable) data principles across the participating infrastructures.

RESULTS

EURO-LABS has been running successfully since its start on September 1st, 2022. Information on the facilities and application templates were provided at the project website [1]. Applications included a scientific proposal describing the scope of the project, with particular emphasis on excellence and novelty, together with the list of team members requesting support. The TNA programme provided funding covering experimental costs as well as travel support for participating users. Applications were collected at the facility level, evaluated by a **User Selection Panel (USP)** composed of experts in the relevant scientific domain and facility area, with the final approval endorsed by the corresponding facility scientific and planning committee.

EURO-LABS has been widely promoted through presentations at conferences, scientific meetings, and outreach activities within the related research communities. By December 2025, a total of 490 TNA projects had been approved, supporting 3557 users across all participating facilities. Particular attention was devoted to diversity and inclusiveness in the allocation of support, considering aspects such as gender balance, nationality, institutional origin, and career stage of the supported users, as illustrated in Figs. 2, 3, and 4.

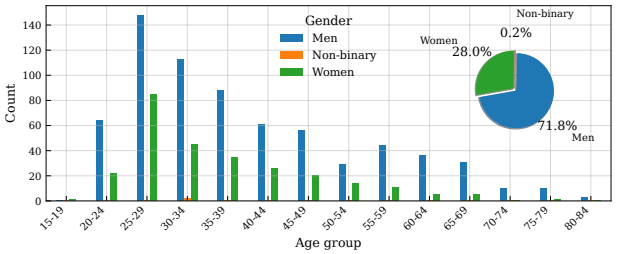

Figure 2: Age-gender distribution for the EURO-LABS supported users in TNA projects.

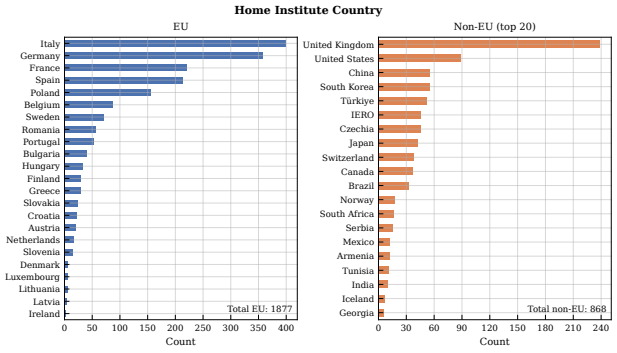

Figure 3: Home Institute origin for the EURO-LABS supported users in TNA projects.

The EURO-LABS Newsletter [4] published periodically collects scientific and community highlights of the project. Key scientific highlights include a report on the FLASH effect radiotherapy R&D aimed at destroying or controlling tumor with Ultra-high dose rate (UHDR; >40 Gy/s irradiation with minimal normal tissue toxicity, realized in GSI-FAIR and CERN-CLEAR facilities of EURO-LABS. Or, the series

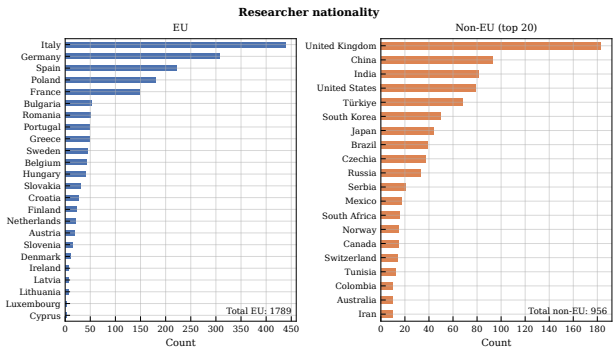

Figure 4: Researcher Nationality for the EURO-LABS supported users in TNA projects.

of experiments at CERN-HiRadMat aimed at producing a lab-analogue of the jets of matter and antimatter that stream out of some black holes and neutron stars. In addition, the release of the first version of the **openNP catalogue** [5], one of the main objectives of the project. OpenNP is a web-based service offering a centralized and FAIR-compliant metadata catalog for nuclear physics datasets, as those produced through EURO-LABS TNA projects.

The training activities within EURO-LABS constitute an important pillar of the project. This objective was successfully pursued through the organisation of nine training schools across Europe, covering both introductory and advanced-level topics. A particular highlight are the three Advanced Hands-On Training Schools on Operation of Accelerators (**ATSOA**) held at CERN in 2024-2026, which provided selected students with a unique practical training experience in accelerator operation in a wide spectrum of accelerators [6].

SUMMARY

EURO-LABS has successfully established a unique collaborative framework that, for the first time within a single European initiative, brings together the Nuclear Physics, High-Energy Physics, and Accelerator R&D communities around a common ecosystem of research infrastructures. The project enabled efficient transnational access to leading facilities across Europe and supported a broad range of scientific activities through its TNA programme. EURO-LABS provided scientists, in particular researchers at early stages of their careers, with the opportunity to realise high-quality projects fostering novel research and technological developments. In addition to its scientific output, the project contributed significantly to training, community integration, and the development of advanced services and methodologies, demonstrating the value of a coordinated cross-disciplinary RI approach at the European level.

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