EURO-LABS Newsletter

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EURO-LABS 3rd Annual Meeting group photo

Advanced Training School on Operation of Accelerators, Courses – Hands-on – Simulations. CLEAR, ISOLDE, & PSB

EDITORIAL

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EDITORIAL

M. Colonna
For the EURO-LABS Team

Dear readers,

The third edition of the EURO-LABS NewsLetter comes a few months after the completion of the second year of the project and the holding of the third annual meeting (TAM) at CERN, from 28th to 30th October 2024. As described in detail in the first article of this issue, by Ilias Efthymiopoulos, TAM was a great occasion to bring together EURO-LABS' three communities - Nuclear Physics, High-Energy Accelerators, and High-Energy Detector R&D - to discuss recent project activities, share the most interesting achievements and plan new synergies and joint actions. The main focus of this meeting was the presentation and discussion of the results arising from the use of the TA facilities over the last two years. European strategies for nuclear and particle physics were also presented in the introductory talks of the meeting, underlying unique and complementary aspects within the EURO-LABS wide community. Collaborative efforts on common topics, like machine-learning-optimized experiment design and computing initiatives among others, were highlighted. EURO-LABS activities aim to align and support the European strategic development plans in the field of nuclear and particle physics. This issue features an article, by Marek Lewitowicz, underlying the close synergy between the support provided by EURO-LABS, with its TA to state-of-the-art European facilities and their improved services, Open Science and training programs, and the recommendation of the latest NuPECC Long Range Plan.

The crucial role played by EURO-LABS for strategic detector R&D, following the guidelines provided by the ECFA, within the European Strategy for Particle Physics (ESPP), is highlighted in the contribution by Marko Mikuz. The TA offered by EURO-LABS is a vital support for upgrading detectors for operation at the High Luminosity Large Hadron Collider (HL-LHC), and for preparatory activities in view of the planned highest-priority next colliders, such as the electron-positron Higgs factory and, for the longer term, the proton-proton collider of the FCC-hh project.

Among EURO-LABS recent activities, the topics selected for this issue range from medical application, with FLASH radiotherapy (by Marco Durante), to service improvements relating to ion beams and targets available for nuclear experiments (by Manuela Cavallaro and Hannu Koivisto) and R&D on superconducting accelerating cavities (by David Longuevergne).

FLASH (ultra-high dose rate) radiotherapy can substantially enhance the therapeutic window of radiotherapy and reduce the treatment time. The EURO-LABS support - both TA and service improvement activities - covers the three FLASH modalities (electrons, protons and carbon ions), establishing an effective synergy and fostering collaborations across different work-packages and participating research infrastructures of EURO-LABS. This activity is carried out at VHEE, at CERN, for electrons, the proton therapy facility at IFJ-PAN, and GSI for 12C-ions.

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The service improvement in EURO-LABS is contributing to the development of targets for high intensity beams and the delivery of ion beams of improved quality in terms of their variety and stability, especially for very high intensity beams. The two tasks are carried out in collaboration among different institutions and will benefit the entire community, with the common goal of increasing the variety and availability of projectile-target combinations for nuclear physics experiments performed at the EURO-LABS research infrastructures.

As a further example of the interdisciplinary nature of the project, with the EURO-LABS support R&D activities carried out at the SUPRATECH platform (IJCLab-France) for accelerator component design and fabrication, are currently dedicated to the Proton Improvement Plan II (PIP-II). This ambitious program aims to provide an intense neutrino beam for the future Deep Underground Neutrino Experiment (DUNE) at FermiLab.

Training the new generation of young scientists is among the main missions of EURO-LABS. The International Basic Training School on Accelerators (BTS24) was held from 18th to 27th June 2024 in Warsaw (Poland), jointly organized by HIL and INCT. The lectures, including hands-on sessions, covered a variety of topics of relevance for heavy ion acceleration, nuclear physics experiments and medical applications (see the article by P. Napiorkowski, U. Gryczka and J. Samorajczyk-Pyśk).

Aiming to catalyze the future of science with collaboration and Open Access practices, the EURO-LABS Advanced Training on Open Science and Data Management was held from 24th to 27th November 2024 at Castle Ebernburg, in Germany, jointly organized by GSI/FAIR and CSIC (see the article by C. Hornung, A. Mistry, A. Lemasson, and M.-J. Garcia Borge). Both events featured a lively participation of students and early-career researchers.

Having almost reached the completion of the second reporting period of EURO-LABS (end of February 2025), we will continue to bring exciting new events to the European scientific community, embracing all the lively project activities. Stay tuned!

Maria Colonna
For the EURO-LABS team

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EURO-LABS Third Annual Meeting - TAM

Ilias.Efthymiopoulos, CERN, Switzerland

The Third Annual Meeting (TAM) of the Consortium took place at CERN from 28th to 30th October 2024. This event brought together 92 participants, representing EURO-LABS' three communities: Nuclear Physics, High-Energy Accelerators, and High-Energy Detector R&D. The attendance matched the levels seen in the Second Annual Meeting (SAM) in Krakow (October 2023) and the Kick-Off Meeting (KOM) in Bologna (October 2022). The TAM served as an opportunity to reflect on the progress of the project, share results, and outline plans for future milestones.

Joachim Mnich, CERN's Director of Research and Computing, opened the meeting with an overview of CERN's activities. He began by highlighting the excellent performance of the Large Hadron Collider (LHC) in 2024, which delivered 124 fb^{-1} of proton-proton data to the ATLAS and CMS experiments. He also showcased key physics achievements, including the updated measurement of the W boson mass by CMS and the first-ever observation of the ultra-rare decay $K^+ \to \pi^+ \nu\nu$, a process occurring once per 10 billion decays and sensitive to deviations from the Standard Model. Joachim then presented the updated schedule for the LHC's Long Shutdown 3 (LS3), which will focus on installing upgrades to the accelerator and detectors in preparation for High-Luminosity LHC (HL-LHC), now expected to begin in mid-2030. Over its projected 10-year operation, the HL-LHC will deliver approximately 3000 fb^{-1} of proton-proton data to ATLAS and CMS, as well as a significant dataset of heavy-ion collisions, of particular interest to the ALICE experiment.

Joachim also emphasized CERN's commitment to its diverse research portfolio, including experiments at the PS Booster, PS, and SPS, such as the recently approved SHiP (Search for Hidden Particles) experiment, expected to begin data collection around 2032. He underscored CERN's future readiness, noting its role in advancing potential collider projects, including the Future Circular Collider (FCC), driven by strong physics motivations.

Navin Alahari, the Scientific Coordinator of EURO-LABS, provided an update on the project's achievements. He highlighted the wide-ranging impact of the experiments supported by EURO-LABS, from fundamental science to practical applications. Specific examples included contributions to public health through FLASH radiography, advancements in sustainability via improved machine learning algorithms for beam control, and a strong focus on training future researchers. Navin presented data visualizations, such as "Manhattan graphs" on user statistics that demonstrated broad participation of users across countries, as well as pie charts showing a 25%-75% gender balance, uniformly distributed across work packages.

He also reviewed the milestones achieved thus far, the approval process for PR1, and the upcoming deliverables. Navin reminded participants of the Period 2 (P2) report deadline, covering the period from September 2023 to February 2024, which must be submitted to the European Commission by April 2025 (M30).

The Monday morning session featured a series of invited talks.

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Marek Lewitowicz presented the updated NuPECC Long Range Plan (LRP2024) for European Nuclear Physics. The plan covers a wide spectrum of physics topics, including among others the formation of the Quark-Gluon Plasma (QGP) in high-energy collisions at facilities like the LHC and FAIR, investigations of the new facets of nuclear structure, reactions and nuclear astrophysics, that will use the various facilities in Europe, and also theoretical advancements. Marek emphasized the societal contributions of nuclear physics, such as its role in sustainable development and medical applications. He encouraged participants to align their future EC funding proposals with the recommendations of the LRP2024.

Paris Sphicas provided an update on ECFA's activities concerning the European Strategy for Particle Physics (ESPP). He reiterated the recommendations of the 2020 ESPP update, including the need for community-wide engagement in the current update process launched in 2024 by the CERN Council. Key dates include the March 2025 deadline for input and the Open Symposium in June 2025, culminating in the final strategy submission to the CERN Council in January 2026. Paris highlighted the scientific case of a potential Higgs-Electroweak-Top (HET) Factory with e+e− collisions, as envisioned in the FCC proposal. He also detailed the ECFA Detector R&D Roadmap and the collaborative efforts between ECFA, NuPECC, and APPEC on shared topics like machine-learning-optimized experiment design and computing initiatives through JENAA. Paris concluded by emphasizing the importance of consensus within the community on the choice of the next collider to ensure its success and provide long-term direction and vision for young researchers.

Jacqueline Keintzel gave an overview of the Feasibility Study for the Future Circular Collider (FCC) at CERN, highlighting its potential as a multi-stage facility. The proposed 91 km ring, based near CERN, could begin as an e+e− collider (90-365 GeV center-of-mass energy) before evolving into a proton-proton collider at ~10 times the LHC's energy. Jacqueline outlined advancements in placement studies, R&D on energy-efficient technologies, and novel magnet designs (e.g., HTS magnets operating at 40° K). She concluded with a roadmap for FCC development, targeting feasibility completion in 2025, possible project approval by 2028, and construction initiation by 2031-2032, pending international support.

Maurizio Vretenar concluded the session by presenting highlights from the I.FAST project on accelerator technologies. Nearing completion, I.FAST has achieved significant R&D breakthroughs in areas such as plasma acceleration, high-brightness beam magnets, HTS magnets, and medical applications. He emphasized the project's strong industrial partnerships (17 companies) and the promotion of innovation through yearly Challenges (e.g. on healthcare applications of accelerators which is the theme of the last two). Maurizio also shared reflections on managing large EC projects, balancing collaboration and administrative demands.

The final invited talk was scheduled for Tuesday morning, where Paolo Giacomelli provided an overview of the AIDAinnova EU project, which focuses on R&D for High-Energy Physics (HEP) detectors.

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Paolo detailed the wide spectrum of activities undertaken by AIDAinnova, including advanced R&D and infrastructure development for detectors at future colliders, as well as the exploration of novel detector technologies and innovative software solutions, such as machine learning modules. He also highlighted the project's collaborative nature, emphasizing its joint R&D programs with industrial beneficiaries, which foster closer ties between academia and industry to drive technological innovation.

In contrast to previous meetings, the TAM program placed a strong emphasis on showcasing scientific results and highlighting progress made through service improvements at the facilities. To this end, Monday afternoon and Tuesday morning were dedicated to a series of highlight presentations from various facilities. These sessions demonstrated the impressive range of physics results achieved with EURO-LABS support across the participating institutions, underscoring the significant impact of the collaboration and the complementarity of the various work packages.

Monday's events concluded with a Cocktail and Poster Session, featuring 42 posters, most of which were prepared by young researchers funded through EURO-LABS. The quality of the presented work sparked great interest and lively discussions, particularly as the mixed EURO-LABS community engaged with diverse perspectives and results. The conversations continued well into the evening, reflecting the enthusiasm and collaborative spirit of the attendees.

On Tuesday afternoon, the Governing Board (GB) session was held, chaired by Edda Gschwendtner. During the session, Edda was unanimously re-elected as GB Chair, and the proposal from the Jožef Stefan Institute in Ljubljana, Slovenia, to host the next annual meeting was warmly approved. The day concluded with the official dinner at a charming restaurant in Geneva's historic old town.

The final day of the meeting included updates from the coordinators of WP2, WP3, WP4, and WP5, who summarized the progress achieved since the last annual meeting and outlined upcoming milestones and deliverables for the next year. Barbara Pezzotta focused on the lessons learned from the preparation of the Period 1 report and presented a detailed plan for collecting the necessary TA data for the P2 report, emphasizing the crucial role of collaboration from all Facility Coordinators. Maria Colonna provided further insights into the schedule and key deadlines to ensure the timely preparation of the P2 report. Stefania Melandri, meanwhile, introduced a strategy to enhance EURO-LABS's visibility on social media and other community platforms, aiming to broaden its outreach and engagement.

The Annual Meetings are a cornerstone among the Consortium's activities. What I will dearly remember from this meeting is the joy of reconnecting with colleagues after a long time, engaging in meaningful discussions, and strengthening relationships.

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Equally significant was the opportunity to interact with enthusiastic students as they presented their results during the featured talks or at their posters.

I am already looking forward to next year's event in Ljubljana.

Ilias Efthymiopoulos, CERN
for the Local Organizing committee: Stephanie, Saamiya, Sabrina, Cloe.

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Figure 1: The social dinner in Geneva's historic old town

Figure 2: Participants attending TAM in the meeting conference hall

Figure 3: The poster session held during the meeting

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NuPECC Long Range Plan 2024 for Nuclear Physics in Europe and the role of EURO-LABS in the European landscape

Marek Lewitowicz, GANIL, France

The Nuclear Physics European Collaboration Committee (NuPECC) http://nupecc.org/ hosted by the European Science Foundation represents today a large nuclear physics community from 23 countries, 3 ESFRI (European Strategy Forum for Research Infrastructures) nuclear physics infrastructures and ECT* (European Centre for Theoretical Studies in Nuclear Physics and Related Areas), as well as from 4 associated members and 10 observers. As stated in the NuPECC Terms of Reference one of the major objectives of the Committee is: "on a regular basis, the Committee shall organise a consultation of the community leading to the definition and publication of a Long Range Plan (LRP) of European nuclear physics". To this aim, NuPECC has in the past produced five LRPs: in November 1991, December 1997, April 2004, December 2010 and November 2017 (http://nupecc.org/pub/lrp17/lrp2017.pdf).

The LRP outlines the strategic developments for nuclear physics research across Europe, aiming to strengthen its scientific and societal contributions. The LRP, being the unique document covering the whole nuclear physics landscape in Europe, identifies opportunities and priorities for nuclear science in Europe and provides national funding agencies, ESFRI and the European Commission with a framework for coordinated advances in nuclear science. It serves also as a reference document for the strategic plans for nuclear physics in the European countries. NuPECC decided to launch the process of creating a new LRP for European nuclear physics in May 2022 and officially presented in November 2024 http://nupecc.org/?display=lrp2024/main.

The whole process of elaboration of the LRP2024 was supervised by a Steering Committee composed of recognized experts in different sub-fields of nuclear science and of representatives of major nuclear physics facilities, Including the chairs of the Astroparticle Physics European Consortium (APPEC) and the European Committee for Future Accelerators (ECFA). The Committee has also invited two observers from the Nuclear Science Advisory Committee (NSAC), USA and the Asian Nuclear Physics Association (ANPhA). The NSAC US Long Range Plan for nuclear physics was issued at the end of 2023 and a strategic plan for nuclear physics in Asia is under preparation by ANPhA.

The bottom-up approach which has always played an essential role in the LRPs, was strengthened by the SC launching in 2022 an open call for contributions to the LRP 2024. The received 159 contributions, submitted by more than 400 individual scientists, collaborations, research infrastructures, and institutions in Europe composed a solid basis for the further analysis and elaboration of the LRP by 11 Thematic Working Groups (TWG). The TWG covered a large set of topics relevant to the development of nuclear physics namely, Hadron Physics, Properties of Strongly Interacting Matter at Extreme Conditions of Temperature and Baryon Number Density, Nuclear Structure and Reaction Dynamics, Nuclear Astrophysics, Symmetries and Fundamental Interactions, Applications and Societal Benefits, Research Infrastructures, Nuclear Physics Tools - Detectors and Experimental Techniques, Nuclear Physics Tools - Machine Learning,

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Artificial Intelligence, and Quantum Computing, Open Science and Data and Nuclear Science – People and Society. Compared to previous versions of the LRP, TWGs on detectors, tools, and topics of current interest were added. Two intense and productive working meetings, hosted by GSI/FAIR in Darmstadt, Germany in October 2023 and in February 2024, were dedicated to the drafting of the LRP recommendations and finalisation of the LRP chapters, respectively. A draft of the full LRP2024 was presented and discussed with the nuclear physics community at a dedicated three-day Town Meeting beautifully organised by IFIN-HH/ELI-NP in Bucharest, Romania in April 2024. The Town Meeting, as well as numerous remarks received before and after it, allowed for improving and completing the initial LRP draft.

Finally, the more than 180-page LRP 2024 document was approved by NuPECC at its meeting in June 2024 in Lund, Sweden.

The publication of the official version of the LRP2024 in its final layout was accomplished at the end of October 2024, and its presentation in front of representatives of all institutions dealing with nuclear physics research in Europe took place at the University Foundation in Brussels on November 19th, 2024.

It is not a role of this short contribution to present or even summarized the recommendations of the LRP2024. They can be found in the Executive Summary of the document as well as in its thematical chapters. The role and importance of the EURO-LABS project are underlined in the LRP2024 in a number of chapters and recommendations ranging from the “Executive Summary” (recommendations for infrastructures), “Nuclear Structure and Reaction Dynamics” (recommendations), “Nuclear Physics Tools” (numerical tools, techniques and resources) to “Nuclear Science - People and Society”. These various important references of the LRP2024 clearly demonstrate that the EURO-LABS project plays an essential role in the integration of European facilities and researchers to advance nuclear physics, and related technologies.

EURO-LABS emphasises collaboration, accessibility, and innovation, aligning with the goals of NuPECC's LRP 2024 to promote transnational access to and the sharing of cutting-edge experimental facilities.

In a longer-term perspective, it is essential to ensure the support of the European Union for nuclear physics via following Framework Programmes and EURATOM initiatives.

Figure 4: From the NuPECC LRP2024 presentation event in Brussels on November 19, 2024

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NuPECC Long Range Plan 2024 for Nuclear Physics in Europe and the role of EURO-LABS in the European landscape

The EURO-LABS and all previously conducted integration activity projects are essential for the further development of the community and its recognition by the European and national funding agencies and policymakers. The LRP2024 can be consulted at the NuPECC Web page: https://nupecc.org/lrp2024/Documents/nupecc_lrp2024.pdf.

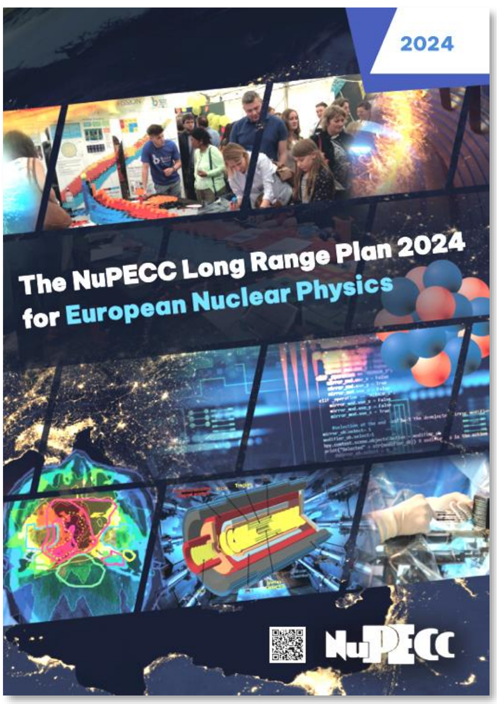

Figure 5: The Cover page of the NuPECC Long Range Plan 2024 and the QR code with link to its full version.

Acknowledgements: The author would like to express his deep gratitude to the 29 members of the Steering Committee, 35 members of NuPECC, 266 Thematic Working Group conveners and members as well as all EURO-LABS colleagues for their invaluable contributions and strong implication in the whole two-year-long process of the elaboration of LRP2024.

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Placing of EURO-LABS in the European Strategy for Particle Physics

Marko Mikuž, University of Ljubljana and Jožef Stefan Institute, Ljubljana, Slovenia

European Strategy for Particle Physics

The European Strategy for Particle Physics (ESPP) and its Updates represent a collective agreement of the European particle physics community on the general directions the field should be heading for. The Strategy Process is launched by the CERN Council establishing the European Strategy Group (ESG) and the Strategy Secretariat. It is started by a bottom-up process, soliciting input from both national and topical communities that is collected by conveners of the Physics Preparatory Group (PPG). The main forum for general discussion is a week-long Open Symposium where PPG conveners present consolidated input. The consolidated community input is composed in the form of a "Briefing Book" and submitted to the ESG. Considering eventual additional input from national communities, ESG prepares the Strategy Document in the Strategy Drafting Session and submits the Draft Strategy to the CERN Council.

The latest ESPP dates back to 2013, and its Update was approved by the Council in 2020. The next Update is planned to be adopted in June 2026 therefore the preparation activities are in full swing. Currently the Strategy Secretariat and PPG are established and inputs being collected. The Open Symposium is set to take place in Venice in June 2025.

Although European in its origin and scope, the ESPP is closely linked to similar strategic processes worldwide, like the Snowmass process guiding particle physics in the United States.

Resulting Detector R&D - Today

Following the stipulations of the 2013 European Strategy for Particle Physics report and their secondment in the 2020 ESPP Update the core endeavour in particle physics detectors today is in the construction of upgraded detectors for operation at the High Luminosity Large Hadron Collider (HL-LHC). The associated detector R&D is almost entirely finished, large orders are being placed and construction activities are well under way to meet the HL-LHC start date in 2030.

A notable exception to the grand picture is the inner tracker part of ATLAS and CMS, where no solution has been found to survive the entire HL-LHC lifetime. Therefore, the plan is to replace the inner pixel detector at mid-point, after ~2/ab of integrated luminosity. While the existing detector solution could serve as a viable replacement, R&D for technologically more advanced detectors is being pursued vigorously. The LHCb experiment will undergo a major upgrade in the first long break (LS4) in HL-LHC operation scheduled for 2034/35. The radiation load to these detectors will be getting close to those of the inner parts of ATLAS and CMS trackers.

Resulting Detector R&D - Future

The 2020 ESPP Update establishes two project initiatives as high priority for the future of particle physics in Europe. As the highest-priority next collider it singles out an electron-positron Higgs factory and for the longer term a proton-proton collider at the

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Placing of EURO-LABS in the European Strategy for Particle Physics

highest achievable energy, dubbed as the FCC-hh project. The ongoing Strategy Update is expected to pinpoint a concrete realization of the Higgs factory to be started, and to become operational at the end of HL-LHC operation in the early 2040's.

The development cycle towards the use of a new technology for particle physics detectors in experiments typically spans over 10 to 20 years. The associated detector R&D can be, according to its Technology Readiness Level (TRL), classified in three categories:

- prospective detector R&D or "blue-sky" research – TRL 1-3
- strategic detector R&D, according to known needs of future projects – TRL 4-6
- targeted detector R&D of approved experiments – TRL 7-9

Strategic (and to a small extent "blue sky") detector R&D for these two goals is currently supported by the AIDAinnova EC project, following up on its predecessors, AIDA and AIDA2020.

To bridge the gap in strategic detector R&D the European Committee for Future Accelerators (ECFA) was charged by CERN Council to develop a roadmap towards detectors needed for the long-term strategy goals. The ECFA Detector R&D Roadmap was composed throughout 2021 and approved by the CERN Council at the end of that year. Therein, long term strategic detector R&D goals (Detector R&D Themes – DRDTs) are defined to enable future experiments stipulated by ESPP, see Fig. 6. The roadmap was followed up by the respective Implementation Strategy approved in September 2022.

The roadmap implementation establishes a structure of CERN based Detector R&D (DRD) collaborations, grouped as follows:

- DRD1 Gaseous Detectors
- DRD2 Liquid Detectors
- DRD3 Solid State Detectors
- DRD4 Particle ID and Photon Detectors
- DRD5 Quantum and Emerging Technologies
- DRD6 Calorimetry
- DRD7 Electronics
- DRD8 Integration

These collaborations are overseen by the newly established CERN Detector R&D Committee (DRDC). In 2023, these collaborations submitted proposals and were approved by DRDC in early 2024 apart from DRD8 which is still being formed.

The DRDs are complemented by the following General Strategic Recommendations (GSR), mechanisms to achieve a greater coherence in detector R&D across Europe through better streamlining of local and national activities:

- GSR 1 - Supporting R&D facilities
- GSR 2 - Engineering support for detector R&D
- GSR 3 - Specific software for instrumentation
- GSR 4 - International coordination and organisation of R&D activities
- GSR 5 - Distributed R&D activities with centralised facilities
- GSR 6 - Establish long-term strategic funding programmes
- GSR 7 - "Blue-sky" R&D
- GSR 8 - Attract, nurture, recognise and sustain the careers of R&D experts
- GSR 9 - Industrial partnerships
- GSR 10 - Open Science

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Placing of EURO-LABS in the European Strategy for Particle Physics

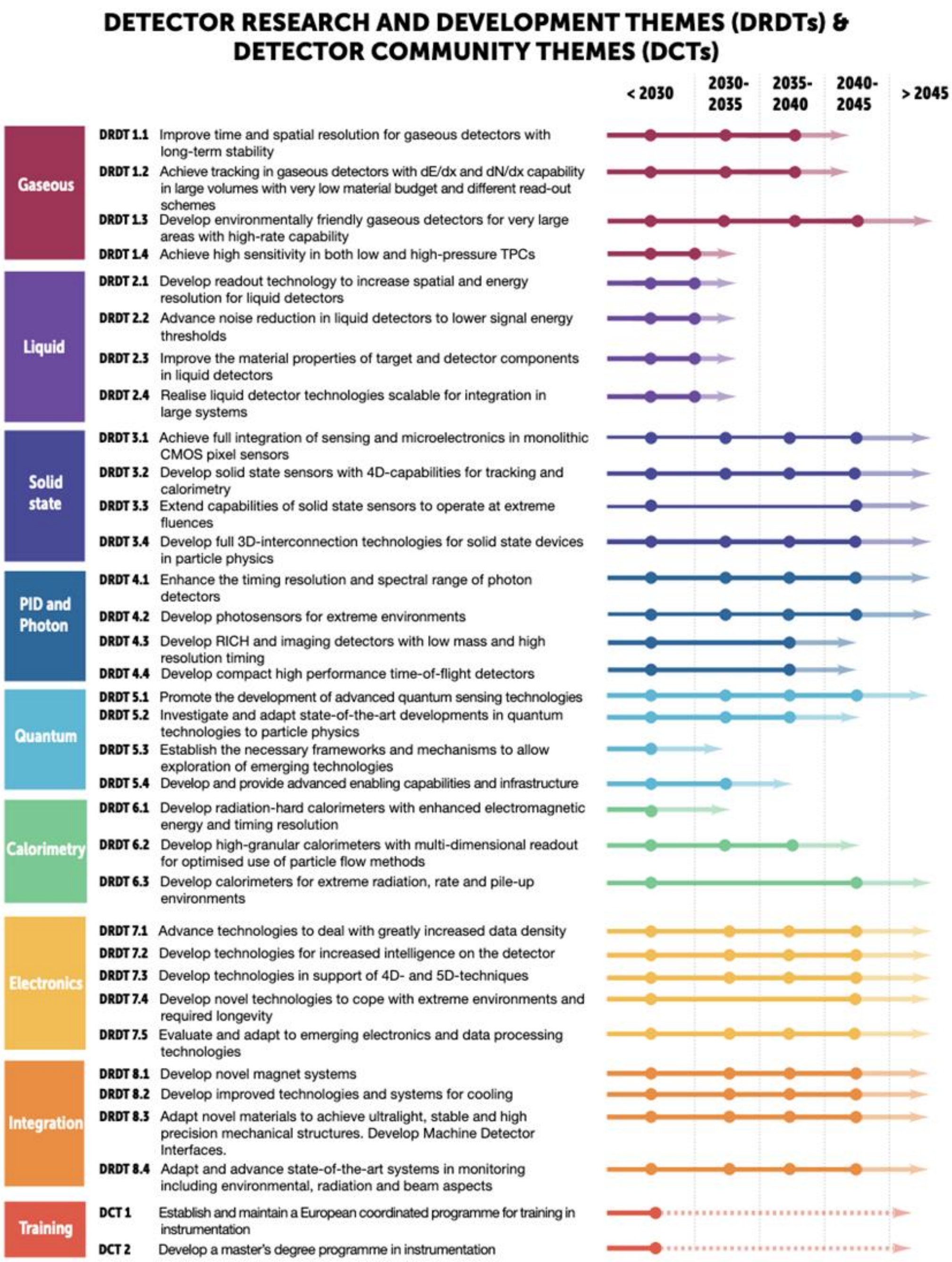

Figure 6: Detector Research and Development Themes (DRDTs) and Detector Community Themes (DCTs) with their respective timelines as identified in the ECFA Detector R&D Roadmap (from Synopsis document).

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Placing of EURO-LABS in the European Strategy for Particle Physics

Role of EURO-LABS

Contrary to its predecessors, AIDA and AIDA2020, the AIDAinnova project incorporates exclusively the Networking and Joint Research instruments, lacking the Transnational Access component. This got remedied by the WP4 work package of EURO-LABS, providing that much needed instrument for strategic detector R&D.

The tasks of EURO-LABS WP4:

- WP4.1 Test Beams,
- WP4.2 Detector Characterization and
- WP4.3 Irradiations

provide Transnational Access resources needed to carry out strategic detector R&D in line with the ECFA roadmap.

The major support of EURO-LABS WP4 for Higgs factory detectors is provided by the Test Beams and Detector Characterization tasks. The envisaged radiation load is relatively small; still testing at low levels of radiation and checking for single event effects (SEE) also calls for usage of the Irradiation facilities.

Detector studies aimed at FCC-hh require highest radiation levels. After the targeted 30/ab of integrated luminosity, forward calorimeters will be exposed to an unprecedented 5000 MGy of ionizing dose (TID) and a fluence of $5x10^{18}$ neq/cm2. Also, the innermost layer of the barrel vertex detectors will suffer to exposures of 10^{18} neq/cm2. Thus, any plausible detector technology for the tracker needs to survive fluences of at least 10^{17} neq/cm2, an effective benchmark for a yearly exchange of detectors in the inner tracking layers.

Nowadays, no detector technology is fit to operate in such an environment. Exploratory measurements of various detectors are being undertaken, and EURO-LABS WP4 can provide access to these conditions, even up to 1018 neq/cm2 in several irradiation facilities of WP4.3. So far, one pioneering neutron irradiation campaign up to 1018 neq/cm2 was carried out, proton irradiations are expected to follow in the coming years.

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FLASH radiotherapy in EURO-LABS

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1. Introduction

Destroying a tumour without toxicity has always been considered the ultimate goal of radiation oncology. Ultra-high dose rate (UHDR >40 Gy/s) radiotherapy has recently emerged as a new modality of irradiation able to maintain tumour control while reducing normal tissue toxicity (FLASH effect). Recently demonstrated in pre-clinical models, FLASH radiotherapy can substantially enhance the therapeutic window of radiotherapy and reduce the treatment time. Ultra-fast treatments could reduce toxicity and enable dose escalation to enhance anti-tumor efficacy. They also would improve patients' comfort, reduce the treatment time and organ-motion related issues, eventually increasing the number of patients that can be treated in a clinic. FLASH is today recognized as one of the most promising breakthrough in radiation oncology standing at the crossroad between technology, physics, chemistry and biology. However, there are several hurdles for translation into the clinic, including understanding of the mechanism, optimization of the parameters, and technological hitches.

2. FLASH@EURO-LABS

The FLASH sparing effects has been observed with different radiation types. The initial results were obtained with electrons, but the effect has been then confirmed first with high-energy protons and carbon ions. Within EURO-LABS, we are covering all three modalities. CERN is building a very high energy electron (VHEE) facility for FLASH. The Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ-PAN) has a proton therapy facility treating patients in Krakow and is working on dosimetry of proton beams at UHDR. Finally, the GSI Helmholtz Center in Darmstadt pioneered FLASH with 12C-ions and is working within EURO-LABS on beam monitors.

3. The CLEAR facility

The CERN linear accelerator for research (CLEAR) is a 200 MeV electron linac followed by a 20 m experimental beamline (Fig.7). CLEAR is R&D infrastructure for new accelerator techniques, including VHEE FLASH.

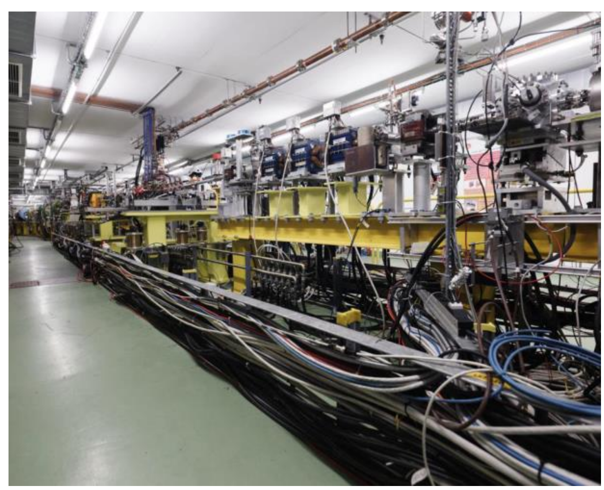

Figure 7: The CLEAR facility at CERN

VHEE are attractive for FLASH because they have a better depth-dose profile than photons and because they are compact and cheaper than proton or ion machines, also thanks to recent advancements in high-gradient acceleration

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101057511.

(CLIC technology). The CLEAR team has developed a number of tools for VHEE-FLASH: The beam delivery is based on a doble-scattering system, radiochromic films are the main passive dosimetry tool and sample handling is performed by the CLEAR robot (C-Robot). The group is now working on real-time dosimetry, a major issue in UHDR radiotherapy. A most promising technology exploits optical fiber arrays, which have no saturation at ÙHDR, good linearity and excellent spatial resolution.

4. UHDR proton dosimetry

The IFJ-PAN group is offering TNA within EURO-LBS at the AIC-144 proton cyclotron in Krakow. The group is testing low gain avalanche detectors (LGAD) for monitoring the proton beam up to 60 MeV. LGAD reproduce very well the signal of the ionization chamber routinely used for beam monitoring. The short (nanoseconds) reaction time of LGAD would allow much faster beam switch-on switch–off in proton therapy than ionization chamber with electrometer. Moreover, LGAD can work at UHDR, having a rising time of 500 ps. The fast silicon sensor LGAD (Fig. 8) has been tested with 60 MeV protons. The detector is able to identify individual protons and to measure correctly the position of the Bragg peak.

5. Heavy ion FLASH

The GSI group in Darmstadt is preforming several UHDR experiments with high-energy 12C-ions. They developed 3D-printed range modulators able to produce highly conformal spread-out-Bragg-peak (SOBP) from a single

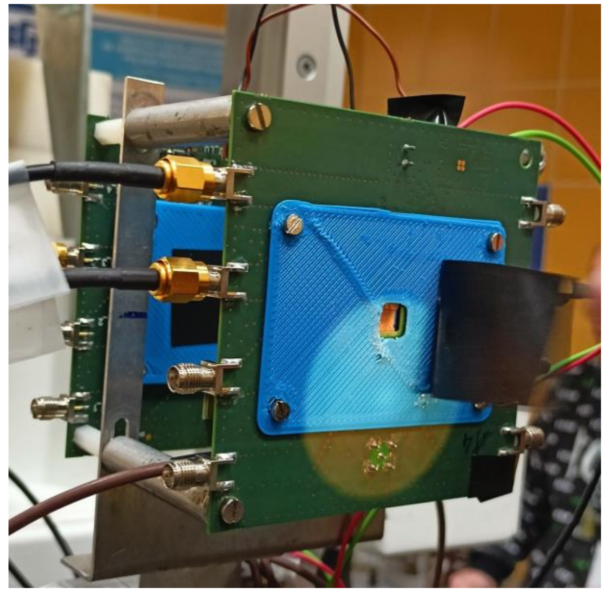

Figure 8: LGAD boards at the irradiation unit

2D-pencil beam scan. This system has been installed in proton therapy facilities in Aarhus (Denmark) and Delft (The Netherlands) for using in FLASH clinical trials with protons. Moreover, the GSI groups is working on the problem of recombination at UHDR and developed a numerical model for charge recombination in the Farmer ionization chamber. The model has been validated in a set of experimental measurements at HIT in Heidelberg with H-, Ne- and C-ions. This model will lead to a new practical workflow for dosimetry of UHDR charged particles.

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Enhancing projectile-target combinations in EURO-LABS Research Infrastructures

Manuela Cavallaro, Hannu Koivisto on behalf of the WP2.5.2 (Targets) and WP2.5.4 (ERIBS) collaborations

The goal of the service improvement in EURO-LABS is to advance the opportunities for users at the state-of-art services of the Research Infrastructures (RIs) involved in the project, making them more attractive and competitive. Among the services offered within task 5 of workpackage 2, subtask 2.5.2 (targets) is dedicated to the development of targets for high intensity beams and subtask 2.5.4 (ERIBS: European Research Infrastructure – Beam Services) is dedicated to improve the quality of ion beams in terms of their variety and stability. The two subtasks are carried out in collaboration among different institutions, for the benefit of the entire community with the common aim to enhance the variety and availability of possible reactions (projectile-target combinations) for nuclear physics experiments in the participating RIs.

The aim of the ERIBS subtask is to improve the beam variety and intensity at EURO-LABS RIs by developing and disseminating best beam production methods and techniques. We also focus on improving both short- and long-term plasma and beam stability, as well as methods for online monitoring of these conditions. Two separate tasks have been organized to fulfil these objectives.

The first one focuses on the methods and techniques to improve the variety and intensity of metal ion beams. Several approaches are used simultaneously to meet these goals. For example, a high temperature oven capable of operating at close to 2000˚C is being developed and will be available for the EURO-LABS infrastructures by the end of the project. Before the end of the project, in addition to this beam development aspect, the MIVOC (Metal Ions from VOlatile Compounds) collaboration concept has been established to make the enriched MIVOC ion beams available to partner institutes. This collaboration is based on the know-how of the CNRS-IPHC team to synthesize several MIVOC compounds in enriched form, which will substantially increase the beam intensity for the users. The MIVOC method know-how is also being transferred to new EURO-LABS research infrastructures to further enhance their production methods for metal ion beams (Fig. 9). The experimental work by several research teams have shown that ion source plasma instabilities have a drastic impact on ion beam production. This leads to degraded beam performance, especially for the high charge states. The instabilities also cause chamber erosion and possible beam contamination. As a second task, low-cost diagnostics to monitor plasma stability are being developed to avoid unstable operation conditions. In addition, online diagnostics for ion beam monitoring are being developed to maintain the requested short- and long-term beam intensity and stability.

More information about the ERIBS project can be found in the following link: https://jyufi-fys.atlassian.net/wiki/x/FgBB

The goal of the “targets” subtask is to gather the community of nuclear target makers, having specific expertise in the field of target manufacturing and characterization, both for nuclear and applied physics purposes.

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Enhancing projectile-target combinations in EURO-LABS Research Infrastructures

Figure 9: Knowledge transfer from the IPHC team to make the MIVOC method available at INFN-LNL.

Different research areas and applications require high quality targets, ranging from fundamental physics (nuclear reaction studies, nuclear data measurements, etc.) and specific targets for charge-strippers and neutron converters, up to the development of isotope-enriched targets for high quality standard medical radioisotope production. Target preparation is often a crucial step on the path towards the success of nuclear physics experiments, or specific final nuclear "products". The recent availability of high-intensity beams at different accelerator facilities in Europe and all over the world pushes the requests for demanding targets, which are resistant to high intensity ion beams while maintaining their characteristics in terms of thickness, uniformity, isotopic enrichment, thermal properties etc.

Specific activities of the "targets" subtask deal with the study of existing and novel materials, the improvement of current and development of novel fabrication techniques, the characterization procedures and the sharing of knowledge among the various facilities. As an example, the new CACTUS (Chamber for Alpha-particle Characterisation of target Thickness and Uniformity by Scanning) setup (Fig. 10) has been installed at INFN-LNS. It has been used to characterize targets in terms of thickness and uniformity, by measuring the energy loss and spread of alpha particles from radioactive source passing through thin target layers. Such method has allowed to characterize and identify the best multi-layer graphene foils to be used as substrate for targets needed for experiments with high intensity beams. At GANIL, isotopic lanthanide targets are under development using physical vapor deposition (PVD) methods. Large area targets of ^{174}Yb on thin carbon of 22 cm² were obtained. In the coming year, the target laboratory will be renovated with three new evaporators needed for the large quantity of targets requested by S3. This subtask will establish a database containing information on the preparation and the characteristics of the targets available and newly developed in the participating institutions. The first version is ready and will be made public in the coming months.

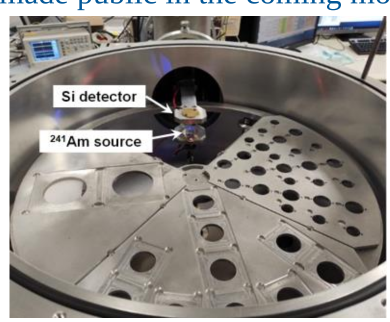

Figure 10: Internal view of the CACTUS chamber at INFN-LNS. The movable plates with holes of different sizes to mount various target frames are visible.

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Cryogenic qualification of superconducting accelerating cavities for PIP-II Project at SUPRATECH platform

David Longuevergne, SUPRATECH, IJCLab, France

The SUPRATECH platform, created in 2004 and supported by Nuclei & Particules Institute of CNRS, IJCLab direction and University Paris Saclay, specializes in R&D on superconducting accelerating cavities, particularly low-frequency resonators (50–500 MHz) designed for future high-power particle accelerators. It is fully equipped to handle quality control, surface processing, cleanroom assembly, and cryogenic testing of superconducting cavities and their associated components, such as RF power couplers and frequency tuning systems. Among several international contributions, SUPRATECH has successfully produced tens of cryomodules (modules housing accelerating cavities) for the SPIRAL2 project at GANIL (France) and the ESS project in Lund (Sweden).

More recently, SUPRATECH is involved in the prototyping phase of the Proton Improvement Plan-II project (PIP-II). This ambitious project encompasses a series of upgrades and enhancements to the Fermilab accelerator complex, aimed at supporting a world-leading neutrino research program for decades to come. Specifically, PIP-II will provide an intense neutrino beam for the future Deep Underground Neutrino Experiment (DUNE). FermiLab has established a global collaboration with experienced international partners in accelerator component design and fabrication to support this ambitious international project, and IJCLab is one of them.

Three prototype superconducting accelerating cavities for PIP-II, like the one shown in Fig. 11, made of bulk Niobium, have been been successfully tested at cryogenic temperatures in a dedicated cryostat as shown in Figure 2 on SUPRATECH platform at IJCLab in University Paris-Saclay campus, France.

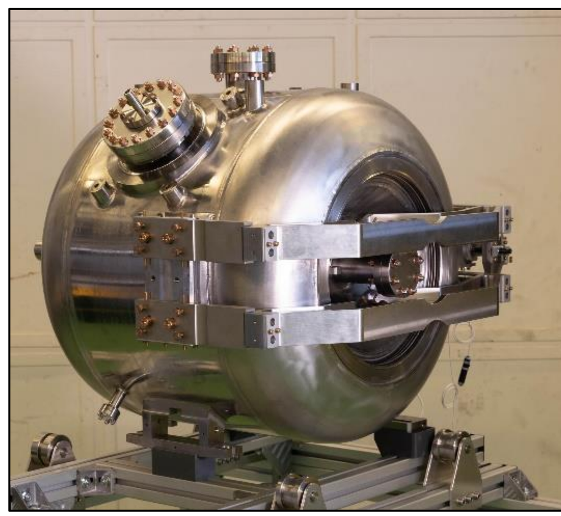

Figure 11: Superconducting accelerating cavity for PIP-II

These tests simulate the exact operating conditions the cavities will face in an accelerator, including ultra-low temperatures (-271° C), ultra-high vacuum (1 × 10^{-8} mbar), and exposure to high-amplitude radiofrequency electromagnetic fields.

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Cryogenic qualification of superconducting accelerating cavities for PIP-II Project at SUPRATECH platform

To qualify for use, the cavities must demonstrate robust mechanical performance, resonate at a frequency of 325 MHz, and dissipate less than 10 watts in the liquid helium bath at the nominal accelerating gradient of 11.4 million V/m (protons passing through the cavity gain approximately 5 MeV of energy).

The three cavities were fabricated and surface-processed by Zanon Research & Innovation (ZRI) SRL in Italy, a company with extensive experience in producing superconducting accelerating cavities for international projects. ZRI was selected to produce these prototypes, and to ensure their performance before shipping to Fermilab in the USA, the cavities must be qualified in Europe.

Figure 12: The test cryostat with the two prototype cavities installed.

All three cavities tested at SUPRATECH met the full specifications of the Proton Improvement Plan-II (PIP-II), as illustrated in Fig. 13, confirming that the fabrication process at ZRI is fully mastered.

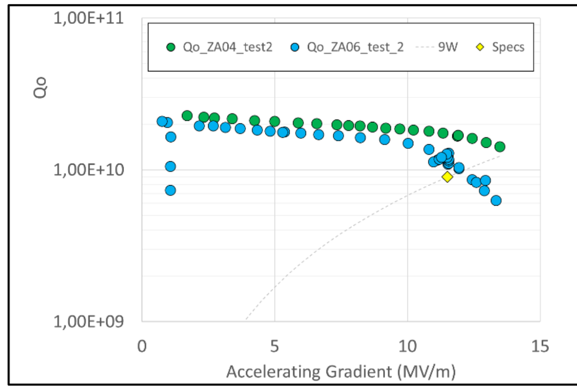

Figure 13: Quality factor versus accelerating gradient of 2 prototypes. PIP-II specifications were exceeded (yellow diamond).

SUPRATECH is one of the few platforms in Europe equipped to test cavities of this size (approximately half a meter in diameter) and weight (~150 kg). The testing of a cavity involves multiple steps, including assembling the cavity onto a dedicated cryostat, performing preliminary checks, cooling it to -271° C with liquid helium, conducting the RF tests, and finally warming it back to room temperature and disassembling the system. The entire process takes about two weeks, involves four people, and consumes 1,000 litters of liquid helium for every two cavities tested.

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BTS24 Basic Training School on Accelerators 2024

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U. Gryczka, Institute of Nuclear Chemistry and Technology, Warsaw, Poland

The International Basic Training School on Accelerators (BTS24) was held between June 18 – 27, 2024 in Warsaw, Poland. The school was jointly organized by the Heavy Ion Laboratory, University of Warsaw (HIL) and the Institute of Nuclear Chemistry and Technology (INCT).

The participants of the school included 18 students and early stage scientists selected from 39 applications. The participants were representative of 14 countries: Argentina, Botswana, Bulgaria, Costa Rica, El Salvador, France, Mexico, Poland, Portugal, Romania, Sweden, Slovenia, Spain, and Ukraine. Young physicists had the opportunity to expand their knowledge following the lectures given by local and international experts and interacting with them. The subjects covered included the detection of ionizing radiation, introduction to gamma spectroscopy, basics of target preparation, fundamentals of nuclear reactions, production of radioisotopes for medical applications, and acceleration of heavy ions. The hands-on activities were performed using a ^{20}Ne beam at the energy of 77 MeV, delivered by the Warsaw Cyclotron and electron beams of energy < 2 MeV and 10 MeV, available at INCT. Participants carried out independent experiments in small independent groups, using the unique research equipment available at the HIL Warsaw, and presented their results during the final session of the school. The students were exposed to the following experimental topics:

- Gamma Spectroscopy
- Fast-timing measurement
- Target production and thickness measurements
- Study of the effects of ionizing radiation on biological material
- Gas/Si telescopes in charge particle spectroscopy,
- Neutron measurements

Figure 14: The Students of the BTS24 school in Warsaw, June 18-27, 2024

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101057511.

BTS24 Basic Training School on Accelerators 2024

Practical exercises were organized at INCT for two days, providing the students with insights into industrial applications of electron beam accelerators and dosimetry methods. The exercises were carried out using two accelerators: 1) the Elektronika 10-10 accelerator generating electron beams with energy up to 10 MeV, installed at the INCT Sterilization Facility, used for both research and commercial scale irradiation; 2) the ILU-6 accelerator. The exercises included measurements with an electron beam with energy of 1.3 and 1.7 MeV.

In addition to the academic activities, there was also time for fun and games: a rope park, air gun shooting, a barbecue and a bonfire, where international hits were sung on the guitar.

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Figure 15: Social event at “"Rancho pod Bocianem"”

Figure 16: The students during experiments at HIL (left) and at INCT (right).

This project has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement No 101057511.

EURO-LABS ADVANCED TRAINING SCHOOL: OPEN SCIENCE AND DATA MANAGEMENT, Castle Ebernburg/GSI Helmholtzzentrum für Schwerionenforschung Germany

Christine Hornung (GSI, Germany), Andrew Mistry (GSI, Germany), Antoine Lemasson (GANIL, France), Maria J.G. Borge (CSIC, Spain)

From 24th to 27th of November 2024, an advanced training course on Open Science and Data Management took place at Castle Ebernburg in the German region of Rhineland-Palatinate. It was performed as part of the EURO-LABS project, with the aim of training the new generation of early-career scientists to maximize the exploitation of data taken at the various European facilities, and thus make them more capable and competitive. https://indico.gsi.de/event/19808/

This training program brought together a diverse group of early-careers researchers, ranging from final year master's students to postdoctoral researchers. Additionally, the school attracted young Open Science professionals, such as data managers. A total of 18 researchers together with 11 tutors attended the school representing institutions in France, Germany, Greece, Portugal, Romania, Spain and Switzerland. The organisation was done by Christine Hornung and Andrew Mistry from GSI/FAIR and Maria J.G. Borge (CSIC), in cooperation with the Helmholtz Graduate School for Hadron and Ion Research "HGS-HIRe for FAIR". The hand-on sessions were developed and conducted by Adrien Matta (LPC Caen - CNRS), Jérémie Dudouet (IP2I Lyon - CNRS), and Antoine Lemasson (CNRS/GANIL). The training aimed to develop skills and knowledge on Open Science principles, including Open data and software, workflows and tools. In addition, emphasis was placed on data and software management best practices to employ throughout the lifecycle of a research project. The lectures were designed to drive the uptake in Open Science and good data management practices, and to encourage the participants to act as Open Science ambassadors for their research communities.

The first day covered a general introduction to Open Science and data management (Antoine Lemasson - CNRS/GANIL), the Basics of Metadata (Özlem Özkan - HMC/HZB), and hands-on introductory GitLab sessions (Florian Uhlig - GSI).

Figure 17: Group photo

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EURO-LABS ADVANCED TRAINING SCHOOL: OPEN SCIENCE AND DATA MANAGEMENT

Throughout the week, the lectures delved into the finer details of reproducible workflows (Elena Sacchi - AIP, Tibor Šimko - CERN), Open Science infrastructures (Andrew Mistry - GSI/FAIR), Open Transfer (Kathrin Göbel - GSI), and examples of Open Science applications in the accelerator-based and astrophysics communities (Harry Enke - AIP, Clemens Lange - PSI). Evening sessions provided an informal environment for further discussions on Open Science ethics, with ideas collected on and debated. A core element of the school was the Hands-On Data Challenge, which took place on every day of the course during the week. Participants applied the methodologies introduced earlier in the course. A succinct analysis of a gamma-ray spectroscopy dataset served as the basis for these exercises. These sessions provided participants with practical experience in implementing data management practices. Working with two differing experimental datasets, they developed important data management skills and gained hands-on experience with relevant software in a collaborative setting. Participants created data management plans, utilised software version control, and generated metadata, demonstrating the importance and benefits of robust data management for enhancing scientific practices. The work was carried out in teams, with team members selected to obtain balanced skill sets across the groups. The groups were requested to share their results between their datasets to improve the scientific outputs through interoperability. The exercise served as a useful learning experience of working together in a collaborative environment.

The results and experiences from the data challenge were shared by each group at the end of the week. In addition to open science activities, participants visited the state-of-the-art GSI facility, which gave them a flavour of the research areas and of the complexity involved in producing diverse, high-quality data. The visit was organised by the FRS facility group, and began with a tour to the FAIR viewing platform, followed by an introductory lecture by Christoph Scheidenberger (GSI) giving an overview of the GSI research fields. Following this, participants visited many of the experimental setups and infrastructures including HADES, SHIP, the FRS, the ESR, the UNILAC, and Tumor therapy hall, the target laboratory, and the Green IT cube. At each setup senior researchers offered detailed and enthusiastic explanations and engaged in Q&A sessions.

Figure 18: Evening session on Open Science ethics

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EURO-LABS ADVANCED TRAINING SCHOOL: OPEN SCIENCE AND DATA MANAGEMENT

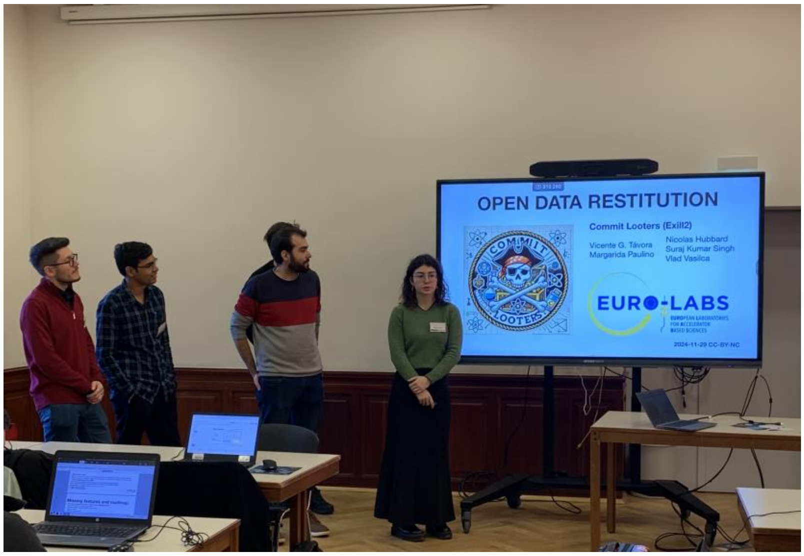

Figure 19: Presentations on the outcomes of the Hands-on data challenge

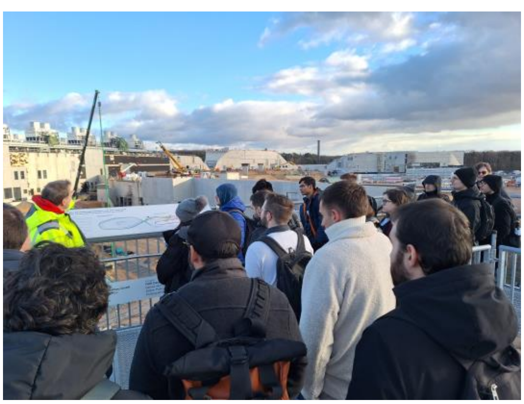

Figure 20: Visit to the FAIR viewing platform

Figure 21: Visit to the GSI Target Laboratory

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Announcement: Advanced Training School on Operation of Accelerators. Courses – Hands-on – Simulation, CLEAR, ISOLDE, & PSB

Building on the success of last year's event, the 2nd Advanced Training School on Operation of Accelerators at CERN (ATSOA25) will take place from May 12 to May 16, 2025. During this week-long program, selected students (trainees) will gain valuable insights into the operation of high-energy accelerators through a combination of theoretical courses, hands-on activities, and practical experience with CERN's accelerators and beams on the PS-Booster, ISOLDE and CLEAR facilities. The subjects to be covered will be: control systems, beam characterization, phasing of SC cavities, mass scans, steering algorithms, collimation and other advanced topics. Trainees are expected to have a basic understanding of accelerator physics and beam dynamics.

Details about the application procedure, eligibility requirements, and key deadlines will be available on the school web page: https://indico.cern.ch/e/atsoa2025.

Participation is fully funded by EURO-LABS, covering:

- Economy-class travel within Europe
- Accommodation
- Daily subsistence support.

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Figure 22: Poster for Advanced Training School