ECFA
European Committee for Future Accelerators

12th ECFA Newsletter

Following the 113th Plenary ECFA meeting
16-17 November 2023
https://indico.cern.ch/event/1220533/

Winter 2023

Table of contents

Introduction 3

Report from the DRD Committee 5

Report from the ECFA - LDG working group on infrastructure for detector R&D 8

Report from the ECFA Training Panel 10

FCC Feasibility Study 11

Second ECFA Workshop on e+e– Higgs/EW/Top Factories, 11-13 October 2023 in Paestum 14

Joint APPEC/ECFA/NuPECC Computing Workshop 15

Proposed Future Activities in the ECN3 Beamline 17

- High-Intensity Upgrade of the North Area's ECN3 17
- HIKE 19
- SHADOWS: a new proposal to explore the Dark Universe 21
- SHIP 23

Plenary ECFA Meeting Reports 25

- The ECFA Early-Career Researchers Panel 25
- Mid-term Report from Poland 27

Introduction

A central element of the implementation plan for the ECFA Detector Roadmap is the formation of Detector Research and Development (DRD) collaborations. After the review of the submitted proposals by the newly formed Detector R&D Committee (DRDC), the CERN Research Board approved five DRDs in different technology areas (gaseous, liquid and solid state detectors, photon and particle ID, calorimeters) and the collaborations will take up their work in January 2024. Two additional proposals (quantum and emerging technologies and electronics) are expected to be submitted in Q1 2024. With the creation of these DRDs, a major milestone in the roadmap's implementation has been achieved. However, work will continue to address other recommendations of the roadmap, such as the availability of detector-R&D-related infrastructure.

In October 2023, the second ECFA workshop on physics and detectors for a future e+e- Higgs factory took place in Paestum/Italy. Good progress was made in the follow-up of the so-called focus topics that were defined at the first workshop. Further studies will continue along the same lines. A third workshop is planned in autumn 2024 and the overall results of the full study will be summarised in an ECFA report, as input for the next update of the European Strategy for Particle Physics.

As far joint ECFA-NuPECC-APPEC (JENA) activities are concerned, the three committees have approved a new proposal on exploring artificial intelligence (machine learning) in the three research areas of particle, astroparticle and nuclear physics. The kick-off workshop for these activities will take place in Amsterdam from 30 April to 3 May 2024.

At the end of November, more than 230 participants from the worldwide particle physics community met at a seminar organised by ICFA at DESY in Hamburg. This was the first such seminar since 2017 and meeting in person was found to be extremely useful and fruitful in discussing the future of our field. We also wish to announce that Pierluigi Campana (INFN Italy) has been elected as the next ICFA Chair for a three-year term starting on 1 January 2024.

Finally, a plenary ECFA meeting was held at CERN in November. In this newsletter you will find short reports on presentations given at this meeting, including on the status of the FCC Feasibility Study, the formation of DRD collaborations and ECFA e^+e^- activities, as well as a report from the Laboratory Directors Group with a focus on progress on accelerator R&D. In addition, in a topical session, the proposals of the HIKE, SHADOWS and SHiP projects for possible future experiments using the ECN3 high-intensity proton beam line at CERN were presented. These reports are also summarised in this newsletter.

At the November meeting, the election by Restricted ECFA of Professor Paris Sphicas (NKU Athens and CERN) as next ECFA Chair, was unanimously endorsed in the closed session by Plenary ECFA. We wish to express our sincere congratulations to Paris Sphicas on this election and we wish him all the best for his leadership of ECFA's activities over the coming three years. During these years the preparation of the next European Strategy process, which must reach convergence on the next large future accelerator project at CERN, will be of utmost importance.

Finally, we would like to take this opportunity to wish all of you a relaxing time over the upcoming holiday season and all the best for 2024.

Karl Jakobs
ECFA Chair

Patricia Conde Muíño
ECFA Scientific Secretary

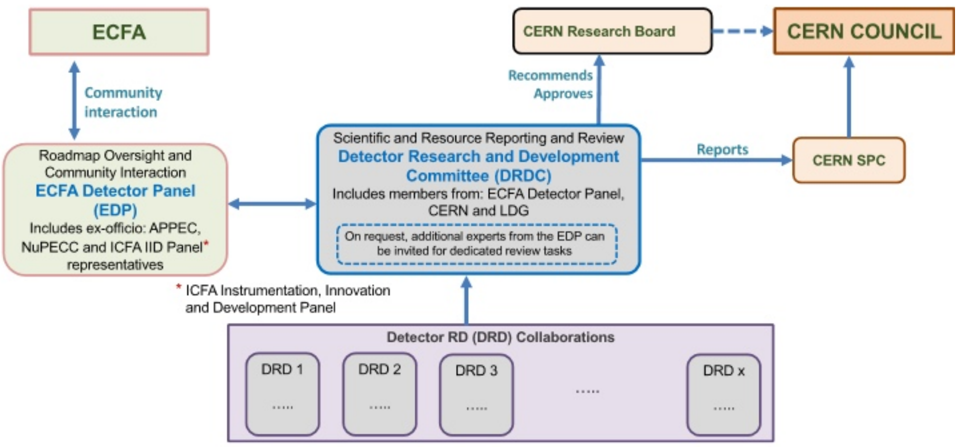
Report from the DRD Committee

by T. Bergauer (HEPHY Vienna), chair of the DRDC

Instrumentation must not be the limiting factor for meeting the needs of the long-term European particle physics programme, as outlined in the European Strategy for Particle Physics (ESPP). Thus, in the last ESPP update in 2020, the community was encouraged to define a detector R&D roadmap, identifying the most important technological developments in the domain of particle detectors required to reach the goals defined in the ESPP. In the period between May 2020 and October 2021, the roadmap was prepared by collecting input from the community, which was eventually collated in a 250-page document and summarised in an 8-page synopsis.

Both documents contain an overview of detectors for future facilities (such as EIC, ILC, CLIC, FCC-ee/hh, muon collider), upcoming non-accelerator experiments, major planned upgrades (e.g. ALICE, Belle-II, LHC-b, etc.) and details of the associated timelines. Six task forces were defined based on various technology domains: **gaseous detectors** (TF1), **liquid detectors** for rare event searches and neutrino experiments (TF2), **semiconductor detectors** (TF3), **photon detectors and particle identification** (PID; TF4), **quantum sensors and emerging technologies** (TF5) and **calorimetry** (TF6). In addition, three more task forces were identified as transversal to the detector technologies: **electronics and online data processing** (TF7), **integration** (TF8), and **training** (TF9). While it was decided to move the last task force on training into the newly created ECFA Training Panel, all other task forces entered another community-driven process, starting in 2022, designed to better define the needs and interests of each community. To this end, each of the task force convenors organised open meetings, which took place between winter 2022 and spring 2023. Based on the presentations made there and input proposals collected by the TFs, proposals for each technology domain were drafted and prepared for submission in July 2023.

In the autumn of 2022, the CERN Council and the Scientific Policy Committee (SPC) endorsed the Detector Roadmap Implementation Plan developed by ECFA (CERN/SPC/1190, CERN/3679). This plan suggests that the long-term detector R&D efforts be organised into larger detector R&D (DRD) collaborations, each to cover a technology domain identified in the Roadmap.



It is proposed in the implementation plan (as outlined in the organigram shown above) that a new CERN committee, the Detector Research and Development Committee (DRDC), be established for the purpose of reviewing the new R&D collaborations, which emerged from the task forces mentioned above. The DRDC is meant to be a new CERN body embedded in the existing CERN committee structure and would ensure rigorous oversight through CERN's well-known and internationally respected peer-reviewing processes.

The DRDC mandate was developed during the autumn of this year. It defines the committee's main tasks as receiving and reviewing DRD proposals, suggesting their approval – when appropriate – to the

CERN Management via the Research Board, and continuously monitoring the progress of each approved collaboration by requesting and reviewing annual status reports. Committee members are appointed by the *CERN Director of Research and Computing* for a two-year term, which can be renewed up to three times. The DRDC contains experts in different detector technologies, as well as members of the ECFA Detector Panel (EDP), including the Panel's chairs as an ex officio member, in addition to a representative of the Laboratory Directors Group (LDG). The Committee has had a heavy workload from its very beginning since it was only established when the first proposals had already been submitted and were ready to be reviewed, at a time when the mandate and working methods of the Committee and the interfaces with ECFA EDP and other groups had yet to be worked out.

Four DRD collaborations submitted their proposals by the deadline of 31. July 2023. These collaborations are **DRD1** (gaseous detectors), **DRD2** (liquid detectors), **DRD4** (photon detectors and PID) and **DRD6** (calorimetry), while **DRD3** (semiconductor) submitted its proposal at the beginning of October. Two collaborations from the ECFA task forces, now named **DRD5** (quantum sensors and emerging technologies) and **DRD7** (electronics), each submitted each a Letter of Intent about their plans to submit a proposal at the beginning of 2024. At the time of writing this text, it has not yet been decided whether a proposal will emerge from TF8 (integration) on cooling and mechanics. In a recent community meeting on these topics held on 6 December 2023, several groups expressed an interest in continuing to work toward a **DRD8** collaboration.

During nine preparatory DRDC meetings, the five proposals submitted were reviewed internally by the DRDC, which resulted in several suggestions for each DRD proposal writing team. Together with additional direct meetings with the proposal writing teams, this feedback led to updates of the proposals, bringing them towards greater consistency with the template provided by the EDP and with the expectations of the DRDC. One goal of the review was to streamline the contents in terms of terminology. Resource-loaded "work packages" (WPs) will be the main work areas, defining milestones and deliverables and reflecting the strategic funding requests. Transversal "working groups" (WGs) will cover topics such as infrastructures, software, tools, outreach and other common activities that are needed for all WPs.

At the first meeting of the DRDC, held on 4 December 2023, each DRD preparation team presented its proposal and answered questions from the DRDC. Based on these presentations and the final versions of the proposals, the DRDC drafted its recommendations and included them in the minutes of the meeting, which have been made public via CDS. At this point I want to congratulate each team for their solid proposals and the considerable interest from each community.

The proposals and the outcome of the meeting were subsequently presented by the CERN Research Board (RB), consisting of the extended CERN Directorate, which finally approved all the collaborations. This decision was made public on the RB board web pages.

The new DRD collaborations

Gaseous detectors have a long heritage in HEP following the invention of the multi-wire proportional chamber (MWPC), which shifted particle detection techniques into the electronic era. Initial further developments such as drift chambers and time projection chambers (TPC) led to impressive sub-detectors for the LEP experiments. The developments in the last two decades have focused on micro-pattern gas detectors (MPGD) such as GEM and micromegas, which were further developed and disseminated by the RD51 collaboration from 2008 onwards. The new **DRD1 collaboration** is building on these successful developments and increasing the scope to include large-volume tracking systems such as MWPCs, TPCs and RPCs. The DRD1 collaboration comprises 700 participants from 157 institutes in 33 countries, which makes it twice as large as its predecessor RD51, and is presented on a newly established collaboration webpage: https://drd1.web.cern.ch. The collaboration held an open meeting on 8 December, where candidates for spokespersons and the CB Chair presented their statements. The first DRD1 collaboration meeting is scheduled for 29 January 2024. DRD1 was approved for an initial period of three years.

The **DRD2 collaboration** aims to develop **liquid detectors for applications in rare event searches and neutrino physics**, in both accelerator and non-accelerator experiments. Several large-scale and many small-scale experiments are running or planned using either noble liquids (e.g. DUNE), water Cherenkov detectors (e.g. Super/Hyper-K) or liquid scintillators with light and ionisation readout. R&D on target doping and purification is needed for multi-tonne noble liquids, and the radiopurity of detector components and background mitigation also needs to be studied. The DRD2 collaboration is expected to comprise participants from 99 institutes in 15 countries. The collaborative effort to build up a research community that has not traditionally worked together in the recent past is to be commended. DRD2 was approved for an initial period of three years.

Semiconductor detectors are a remarkable success in HEP, with detector areas having increased by one order of magnitude each decade: 1 m^2 (vertex detectors at LEP, e.g. DELPHI) → 10 m^2 (e.g. CDF, where vertexing was extended to tracking) → 200 m^2 (CMS tracker) → 600 m^2 (CMS HGCal). The **DRD3 collaboration** aims to continue this success and the work of RD50 (radiation-hard silicon and other materials), RD42 (diamond) and RD53 (FE-ASICs), and is extending the scope even further by an enlarged WP on monolithic CMOS pixel sensors and another WP on 3D integration. DRD3 is expected to be made up of 900 participants from 129 institutes in 28 countries, which makes it twice as large as RD50. While the collaboration is planning to meet to form a collaboration board at the end of January, the first full collaboration meeting is not planned until June 2024. The CERN Research Board urged faster progress in establishing the collaboration bodies in order to speed up this process.

The **DRD4 collaboration** aims to develop **photon detectors and particle identification** devices. It is made up of participants from 74 institutes in 19 countries, including many small groups with no prior experience in large collaborations. Nevertheless, the community-building effort, bringing these groups together, is seen as very positive. Scientifically, the work is focusing on the development of photon-detectors like MCP-PMTs, SiPMs, vacuum, and gaseous photon detectors and their application in ring imaging Cherenkov detectors (RICH), time-of-flight (ToF) and transition radiation detectors (TRD). The collaboration plans to hold a constitution meeting on 23 and 24 January 2024 to elect spokesperson(s) andWP, WG and task leaders. DRD4 was approved for an initial period of three years.

Finally, the **DRD6 collaboration** aims to develop calorimeters, demonstrating the feasibility of a large prototype, with a focus on future Higgs factories. The DRD6 collaboration is expected to comprise participants from 132 institutes in 29 countries and has emerged from several organisations including CALICE, CrystalClear (RD18), FCAl, GranuLAr, CalVision and EU projects such as AIDAinnova, Euro-Labs, the CERN EP-R&D exercise and several proto-collaborations (ILC, Clicdp, FCC, etc.). R&D in calorimetry has a particularly long lead-time due to many technology developments elsewhere (gas, scintillator, silicon-based readout) and large and challenging prototype set-ups, even in the early stages. Thus, a dedicated beamline at the SPS is requested after LS3. DRD6 plans to hold a proto-collaboration meeting around mid-January 2024, where decisions on collaboration bodies will be made. A kick-off meeting and a first Collaboration Board meeting are planned for April. DRD6 was approved for an initial period of three years.

With the initial approval of these collaborations, entries in the CERN Greybook database will be made so that the team leaders of participating groups can be appointed and members can be registered as CERN users. However, the collaborations are independent of CERN and will now start to define their own structures while respecting the framework of CERN's General Conditions for Experiments. They are encouraged to appoint their new management structures quickly, following broad consultation to ensure representation of the whole collaboration. This is especially important for those DRD collaborations that need to ensure the continuation of the ongoing activities of their predecessor collaborations. As a consistent starting point for all meetings and events, respective categories in CERN Indico have been created under "Experiments → R&D".

Moreover, all the groups participating in each collaboration are expected to sign a "lightweight" memorandum of understanding (MoU), which does not contain strategic funding requests. This MoU will regulate intellectual property (IP) topics and the definition and implementation of a common fund, if so deemed necessary by each collaboration. It will be based on a template that CERN will provide. It is also expected that negotiations with funding agencies for strategic funding will be initiated by each DRD through their participating institutes, leading to redefined work packages and deliverables. These are to be set out separately for each work package in the annexes to the respective MoUs.

Finally, all DRD collaborations will present their proposals to the public at the open session of the next DRDC meeting on 4 March 2024 and will then provide status reports annually to the DRDC thereafter.

Report from the ECFA - LDG working group on infrastructure for detector R&D

by S. Bentvelsen (Nikhef), M. Mikuž (University of Ljubljana and Jozef Stefan Institute)

As stipulated in the *ECFA Detector R&D Roadmap* and its implementation plan, Detector R&D (DRD) collaborations are quickly coming to life. At the latest CERN Research Board session, five of them have been approved to start on 1 January 2024, and others are expected to follow shortly.

The joint *ECFA-LDG Detector R&D Infrastructure Panel* was established to assess the infrastructure needs of the emerging DRD collaborations that are not available within the DRDs themselves but might be available in large national laboratories (LDG) or institutes/universities throughout Europe (ECFA). The Panel is composed of 15 members, respecting regional coverage, with a strong ex-officio representation of the LDG, ECFA and the ECFA Detector Panel.

The Panel's first step was to conduct two surveys. The first was designed to identify the needs of the DRD communities, and the second to map out the availability of relevant resources in Europe. Two sub-committees, each comprising three Panel members, were formed to prepare and execute these surveys.

DRD Resources Request Survey

The survey was hosted by Nikhef using the Survio tool. The survey contents were finalised after a couple of sub-committee meetings, then discussed within RECFA and presented at an LDG meeting. A total of 43 questions were posed in the survey. It was distributed to DRDs in mid-June. Each sub-committee member approached 2-3 DRDs. Most of the DRDs considered that the survey had been launched too early, but still appreciated the effort made to conduct it.

Feedback has been received from all DRDs:

- 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

The results are available on the Indico page for the 113th PECFA meeting, in the form of an anonymised version of the survey.

The main message from the survey is a clear request to the LDG (and beyond) to provide infrastructure that is not present within institutes participating in the DRDs. The research infrastructures currently provided free of charge for detector R&D under the EU-sponsored EURO-LABS project provide a good starting point but do not fully satisfy the DRD wish list.

Labs Resources Supply Survey

The involvement of national and regional laboratories in this survey targets the implementation of the following General Strategic Recommendations (GSR) of the *ECFA Detector R&D Roadmap*:

- GSR 1 - Supporting R&D facilities
- GSR 2 - Engineering support for detector R&D
- GSR 3 - Specific software for instrumentation
- GSR 5 - Distributed R&D activities with centralised facilities

We have set up a survey to create an inventory of the resources available in these laboratories. Based on the results, we will try, in a next step, to compare these resources with the requests of the DRDs. The survey aims to gather information and seek a match with DRD needs. Our goal is optimise the Detector R&D efforts and potentially provide the (national) laboratories and universities with new opportunities to acquire funding for these activities.

The survey is structured according to the following types of infrastructure:

- Test-beam and irradiation facilities
  - Existing facilities
  - Plans and ambitions
- Characterisation and test-bench measurement facilities
- Local expertise (status and ambitions/plans)
- Electronics expertise
- Mechanical expertise
- Software support

The responses received by the date of the PECFA meeting consisted of replies from 47 national laboratories, institutes and universities in 12 countries. In some countries the yield is excellent, but we are still facing large gaps in the pan-European coverage, as ECFA covers 28 countries.

It has therefore been decided to keep the survey open for further submissions. RECFA delegates have been asked to contact the relevant institutes within their country to secure an adequate response. To date, responses from 74 institutes have now been received.

We aim to conclude the survey by the end of the year. In the follow-up, we will try to match the DRD requirements to the available resources. This will require substantial work to interpret the survey data in a meaningful way. Many laboratories are actually already deeply involved in the DRD activities. We hope to identify areas where the institutes can and should step in by supplying resources. On the other hand, once we identify the *missing* infrastructures, we can approach funding agencies to explore how laboratories can be supported in order to provide the adequate infrastructure. The final aim of this process is to provide the detector R&D infrastructure needed to make this part of the *ECFA Detector R&D Roadmap* a success.

Resources:

Talk at 113th P-ECFA Meeting (https://indico.cern.ch/event/1220533/):
DRD Survey Summary:
https://indico.cern.ch/event/1220533/contributions/5636996/subcontributions/447794/attachments/2754134/4795018/survey-report-drd-ldg-ecfa-survey.pdf
EURO-LABS Project:
https://web.infn.it/EURO-LABS/

Report from the ECFA Training Panel

by E. Garutti (Hamburg University)

The Detector R&D Roadmap was formulated to define the essential technological advancements needed to realise the vision outlined in the 2020 update of the European Strategy for Particle Physics. Recognising the need for expertise across various cutting-edge technologies and considering the long time scales expected, the Detector R&D Roadmap acknowledged that detector development must be complemented by a well-balanced training programme for the upcoming generations of detector developers required by both the scientific field and industry.
In line with the Roadmap's implementation plan, ECFA established a training panel to work on four main tasks:

1) Redesign the ECFA web page to include a prominent page on training
   the ECFA web page is outdated and does not speak to the early-career researchers who may be interested in getting involved in this field of research. We intend to redefine the content of the ECFA Training web page to include a list of regular schools, details of hands-on events in the detector and accelerator fields, a list of institutes offering Master's degrees in instrumentation or similar courses, a suggested curriculum for a career in instrumentation physics, and information about career path options in the field with sample testimonials. Additionally, we would like to create a network of people active in the field on Linked-in.

2) Collate and coordinate schools in instrumentation
   with this task we intend to coordinate the aims, dates and course contents of the schools proposed on a regular basis by the instrumentation community and discuss missing activities and needs to develop further hands-on courses. We aim at a more coordinated access to training, with specific attention given to geographical distribution, availability of stipends and the promotion of diversity among attendees.
   Via the ECFA training web page we will also advertise the schools in a centralised manner for the community. For the first meeting we invite all school organisers to join us in a zoom exchange on **8. April 2024, 15:00-17:00**.

3) Organise an EU Master's programme in instrumentation
   This is a longer-term project in which we intend to prepare a document with a "possible" curriculum in instrumentation to be discussed with stakeholders who could be interested in applying for EU funds to establish trilateral Master's programmes (similar to Erasmus-mundi), bringing together institutes with large infrastructures and "less privileged" universities with strong experimental competences across Europe.

For all of these projects we are looking for volunteers to support and drive some of the activities. If you are interested in contributing, please contact: Erika.Garutti @ uni-hamburg.de

FCC Feasibility Study

by M. Benedikt, F. Zimmermann (CERN)

As reported previously (ECFA Newsletters 7, 8, 9, 10 and 11), the Future Circular Collider (FCC) Feasibility Study (FS) team is mandated to deliver a Feasibility Study Report (FSR) by the end of 2025.

In this article, we report on the progress made on (1) implementation activities, (2) civil engineering, (3) cooling water supply concepts, (4) site investigations and environmental studies, and (5) excavation material management. We also provide an update on the Feasibility Study mid-term review.

Regular meetings are held with the 41 individual municipalities in France and Switzerland that are potentially impacted by the proposed FCC project. A team at FNAL performed a generic surface civil engineering study for the experimental and technical sites. Figure 1 presents examples of FNAL deliverables. The bills of quantities extracted from the FNAL designs are the basis for cost estimates by consultants with experience of industrial construction projects in the Swiss-French region. The next steps are individual integration studies and design optimisation in close collaboration with the municipalities concerned.

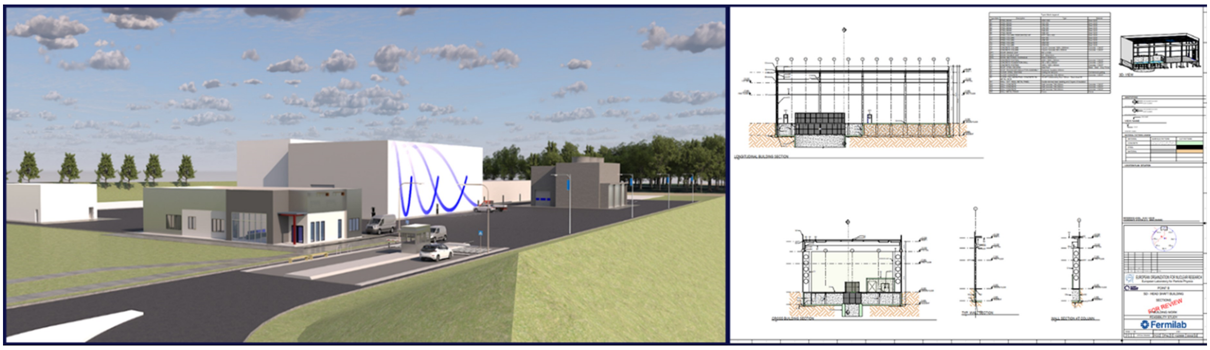
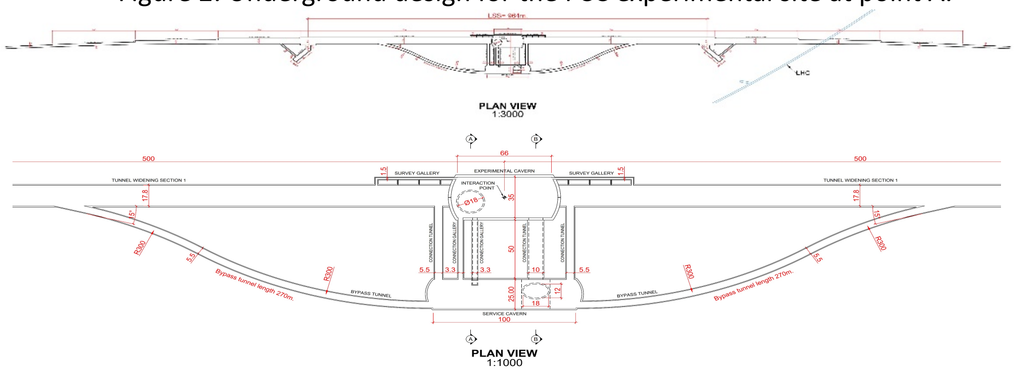


Figure 1: FCC surface site developed by the Fermilab team (Courtesy FNAL)

The underground civil engineering design has also progressed well. Figure 2 shows the underground design for the experimental site around FCC point A (near CERN). A full 3D model of underground structures was established for all the sites. This model serves as the basis for the costing exercise. Scheduling and cost estimates have been updated with the help of an external consultant. The next steps include the adaptation of the vertical alignment and tunnel tilt, and a revision of the construction methodology, with input from the first site investigations campaign, scheduled for 2024-25.

Figure 2: Underground design for the FCC experimental site at point A.



Potential sources of FCC cooling water are Lake Geneva (at point A), the Rhone (at point J) and the Arve (at point D). The existing lake water supply provided by the Swiss public company SIG at LHC point 8 (LHCb) would be sufficient for the FCC-ee. However, the exploitation of the two other sources offers great synergies with local development projects. Pipework in the tunnel would connect the remaining points to the three points A, D and J, as shown in Fig. 3. The main cooling towers would be placed at the experiment points (PA, PD, PG, PJ), and at the RF sites (PL, PH).

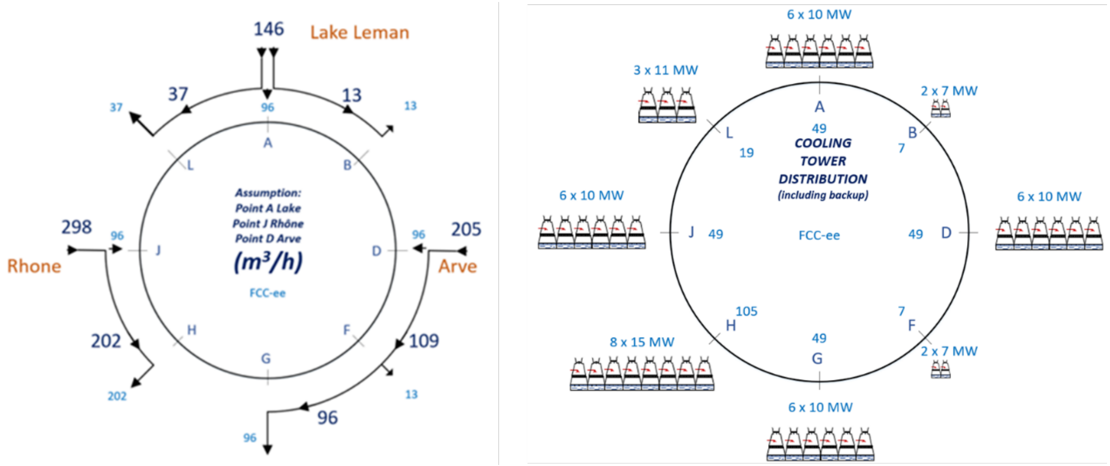


Figure 3: FCC cooling water supply concept.

The FCC tunnel implementation has an optimised circumference of 91 km. A large fraction of this tunnel is located in the molasse, which minimises the construction risks. The implementation involves only 8 surface sites, which each occupy an area of about 5 hectares. A first sub-surface investigation campaign is planned in areas with uncertain geological conditions. Optimisation of the location of drilling locations is ongoing through site visits and environmental studies that began at the end of 2022. Work with France and Switzerland is under way to obtain authorisations for the start of seismic investigations and drillings in the second quarter of 2024. A contract for engineering services has been in place since July 2022. Tendering for execution contracts is in progress with a view to placing contracts in December 2023 and mobilisation from January 2024 onwards.

Studies of relevant environmental aspects have been carried out over the past 18 months with a consortium of specialised companies. Their results are a prerequisite for the required initial state report, which will be followed by an environmental impact assessment. Examples of field investigations and environmental studies include an inventory of fauna and flora on surface sites, the identification of protected species, a description of the surrounding areas, the views to be preserved and architectural aspects to be considered, and the determination of the quality of the topsoil, potential pollution and the economic land value.

An innovative local approach is being pursued for the excavated materials, as illustrated in Fig. 4. The excavated material from FCC subsurface infrastructures amounts to 6.5 Mm^3 in situ and 8.4 Mm^3 excavated. In 2021-2022, the international competition “Mining the Future” led to the development of innovative and realistic ideas for the reuse of the molasse (95% of excavated materials). As a result of this competition, the “OpenSky Laboratory” project was defined in 2023. Its objective is to develop and test an innovative process to transform sterile “molasse” into fertile soil for agricultural use and afforestation. For this project, about 3,000 m^2 of land has been allocated at LHC point 5 in Cessy, France. After an initial laboratory analysis to identify the most suitable processing means, the molasse will be mixed and spread with amendments on the trial cells. Planting and treatment will proceed in a controlled environment. The duration of the OpenSky Laboratory project is 4 years (2024-2027).

To be able to start the excavation of the first shafts in 2033, a significant amount of preparatory work is required. An initial evaluation of this preparatory work, including scheduling and resource aspects, has been made. Key dates are an anticipated project approval in 2028, tender design in 2029-2030, the award of civil-engineering construction contracts by mid-2032, and groundbreaking in 2033.

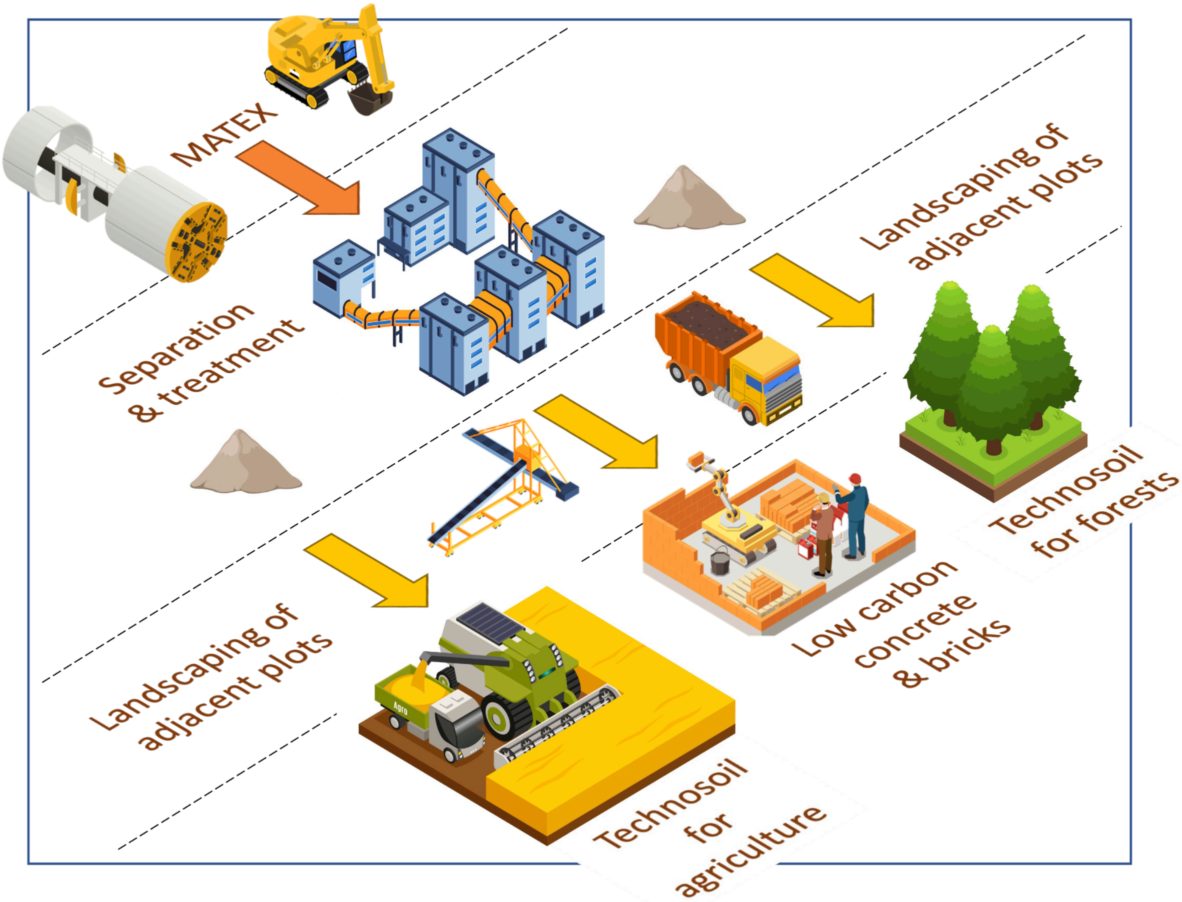


Figure 4: Excavation material management (Courtesy Johannes Gutleber).

The set-up and deliverables for the FCC Feasibility Study mid-term review are defined in document [CERN/SPC/1183/Rev.2](). In accordance with the described process, the FCC FS Scientific Advisory Committee (SAC) reviewed the scientific and technical results, while a special "cost review panel" (CRP) including external experts, as proposed in document [CERN/3588](), assessed the cost and financial feasibility, with a focus on the first-stage project (tunnel, technical infrastructure, FCC-ee machine and injectors).
Both the SAC and the CRP formed expert groups for individual domains, which interacted with theFCC team. More than 30 topical review meetings were held during August and September 2023. A final overall review meeting involving both the SAC and the CRP, together with the FCC team, took place on 16-18 October 2023. The complete set of documentation was submitted to the CERN Council's sub-committees, the Scientific Policy Committee and the Finance Committee, which held special meetings from 20 to 22 November. They are due to submit their resulting reports to the Council by 31 December 2023. A dedicated Council meeting on the FCC FS mid-term review is scheduled for 2 February 2024.
In conclusion, the first half of the FCC Feasibility Study will soon be completed with the end of the mid-term review. The focus in the period 2021 – 2023 was on identifying the best placement and layout, and adapting the entire project to the new placement. The resulting optimised layout served as key input for the mid-term review. The progress was aided by fruitful collaboration between scientific and technical stakeholders, in close cooperation with the Host State services concerned at departmental/cantonal and local level. Direct exchanges are taking place with the communes where surface sites could be located. Environmental studies are ongoing. The focus for 2024 – 2025 will be on subsurface investigations, on further optimisation of the implementation, surface sites and synergies, etc., and on a full design iteration with a view to the technical and cost optimisation of the entire project.

Second ECFA Workshop on e+e− Higgs/EW/Top Factories, 11-13 October 2023 in Paestum

by P. Koppenburg (Nikhef)

The ECFA physics, experiment and detector study on an e^+e^- Higgs, top and electroweak factory was initiated in June 2021, following the recommendation of the European Strategy update, which set an electron-positron Higgs factory as the highest priority for the next collider [1]. The study is organised by three interconnected working groups covering physics (WG1), analysis methods (WG2) and detector development (WG3). See Ref. [2] and the documentation on the new gitlab website. Each WG organises regular topical workshops [4] and holds a plenary workshop once a year. The first plenary workshop was held in Hamburg in October 2022 and was followed by a second workshop held in Paestum near Salerno in October this year. The somewhat remote location (a nice 15-minute walk from the beach) was the perfect setting for a workshop, getting all participants together in the same hotel to encourage discussions and foster collaboration. It was attended by 138 registered participants – slightly fewer than in Hamburg, due to the less accessible location – who presented 117 contributions in plenary sessions and in 4 or 5 parallel sessions.

The WG1 physics studies have identified 14 focus topics. These do not aim to map the physics programme comprehensively, but rather highlight places where work could usefully add to the overall picture, and give guidance to people who would like to contribute to the ECFA study. Topics span a wide range of physics interests, from Higgs studies to searches for exotic particles or challenging measurements in heavy-flavour physics. During the plenary workshop, experts and interested physicists met in parallel sessions to outline the work needed towards the final ECFA report, and also to share new ideas and discuss their latest studies. The first step will be a document to be placed on arxiv soon, presenting each topic and the required work. It should serve as an invitation to join these studies and foster a community with a physics vision beyond the HL-LHC.

In Paestum there were a large number of well-received plenary talks of overall excellent quality. Some already quite advanced focus topic groups presented the status of their work, notably on the Higgs self-coupling, its coupling to strange quarks and the potential of top quark decays for BSM searches. The plenary sessions also featured presentations on detector R&D, including presentation of some new DRD programmes, a discussion of software tools and a status report on the various accelerator projects. The US community gave a very positive message of support for an e+e− Higgs factory.

Topical plenary sessions included a well-attended key4hep software tutorial on the day before the workshop, and a session organised by the early-career researchers panel. A panel discussion featuring a science historian discussed the communication around the project and what to learn from mistakes made in the past. We face the challenge of convincing multiple communities of the need for a Higgs factory in clear words. These communities range from the general public to politicians, decision makers and other scientists, including members of the HEP community.

There were lively discussions, which focused on physics and technologies and fostering a sense of togetherness with a common goal, namely an e+e− Higgs/EW/top factory to be built in the not-too-distant future. The participants left Paestum with plenty of ideas but also a lot of work ahead of them. A further plenary workshop will be organised in October 2024, with a view to converging on a final ECFA report in 2025 that will be input for the next European Strategy update in 2026–27. The whole community is strongly encouraged to consider how they can individually contribute to the study and towards the future success of the field. In particular, early-career researchers are invited to "dive" into the topic, like the Paestum diver ("il tuffatore") on the workshop poster, and should be encouraged to do so by their supervisors, as it is their generation who will operate this facility.

References:

[1] J. List, ECFA Newsletter 11

[2] J. Alcaraz, G. Marchiori, F. Piccinini, A. Robson, ECFA Newsletter 9

Joint APPEC/ECFA/NuPECC Computing Workshop

by G. Stewart (CERN)

The need to address the strategic computing infrastructure needs of major sciences in a coherent manner is urgent. Many new experiments with significant computing needs (CBM, NUSTAR, CTA, KM3Net, etc.) will come online soon, while others, such as ATLAS and CMS at HL-LHC, will be upgraded with much increased requirements. All of this will put more pressure on facilities to deliver very significant computing resources to a wide range of sciences. At the Madrid JENA Symposium in 2022, and in discussions with the funding agencies there, the strong desire was evident that ECFA, APPEC and NuPECC should work together to discuss the strategy for and the implementation of European federated computing at large facilities.

This process began at the JENA Bologna Computing Workshop in June 2023. The three communities came together with the aim of finding synergies, understanding differences and discussing how we can scale up coherently in the years to come.

What were the key questions to be addressed? First, what are the anticipated main issues in software and computing? What federated structures exist in Europe and how can we use and work with them? How is technology expected to evolve and how would this help, or hinder, our mission? What federated models for computing exist and how would they evolve? Finally, how will FAIR (findable, accessible, interoperable and reusable) policies for data and software impact us and how can we deliver on an open science policy? All this was looked at with a European focus but with worldwide implications firmly in mind.

Each community identified some key issues for the challenges to come. In particle physics the computing model for the LHC – the WLCG – is well established and is growing to encompass additional experiments. However, the needs for the HL-LHC, from 2029 onwards, are still extremely challenging to manage, despite impressive advances in software performance. In nuclear physics the FAIR facility will greatly increase data rates and computing needs, but we also need to effectively support many smaller experiments and to find common solutions for this. In astroparticle physics, the challenge is to generalise access to computing resources and give scientists access to data from many observatories in the era of high alert rates and multi-messenger astronomy.

All of these challenges must be addressed in an evolving European computing landscape. The ESCAPE project has done good work in providing a general data management toolkit (the data lake), consisting of common components such as Rucio, FTS, CVMFS and storage infrastructures. This benefits all players as more communities provide support and sites can have a consolidated infrastructure. The European Open Science Cloud (EOSC) targets the open sharing of scientific knowledge and the lifecycle of data products, algorithms and software. This aligns well with the Joint ECFA-APPEC-NuPEC Expressions of Interest in dark matter and gravitational waves. Incorporating the FAIR (findable, accessible, interoperable, and reusable) principles into data lifecycles requires technical support and cultural evolution, so we need to reward and, eventually, require this adoption. Europe is also investing heavily in high-performance computing, through the EuroHPC project, where we need to understand and engage with these new facilities to ensure that they can be used in our worldwide distributed computing systems. It is notable that Germany has decided to close down its university based WLCG Tier-2s in favour of HPC resources, making seamless access vital.

HPC centres also heavily favour GPU computing. This is no accident, given the evolution towards more and more parallel processing as Moore’s Law continues to hold (for now!), but the processing power of a single core is improving only marginally. This processing model is not traditionally used in ENA areas, and it is not easy to adapt to it without significant investment. However, this heterogeneous software landscape seems inevitable, and the challenge is to adapt our codes in a sustainable way, given the complex landscape of different vendor offerings.

These discussions allowed us to hone in on the key points that need to be examined in detail. These are:

- High-performance computing, to understand our relationship with new HPC centres and to shape the latter’s policies on ENA sciences in order to augment our computing capacity.
- Machine learning and artificial intelligence, to understand the resource needs arising from the shift to ML and to define the interfaces that physicists will need to be able to run ML workloads.
- Federations and FAIR, to continue the work of ESCAPE and develop solutions for federated identities and data management.
- Training, dissemination and education, to build on the experiences of training schools and HSF-IRIS-HEP initiatives for training in our field, and to see if a European masters programme in software and computing would be possible.
- Software and heterogeneous architectures, to understand how to increase the efficiency of our code by factors employing new architectures, by rethinking algorithms and engaging research software engineers to work with us on software R&D.

The new CINECA Leonardo supercomputer in Bologna, one of the facilities funded by EuroHPC that will be important for ENA sciences. (Photo: G. Stewart)

Five working groups are needed, which will delve into the details of these key areas in order to produce a white paper in time for the next JENA symposium in spring 2025. This will be the ideal opportunity for software and computing experts in the ENA areas to work together, providing the guidance needed to direct European computing infrastructure in the right direction for the next decade.

Proposed Future Activities in the ECN3 Beamline

High-Intensity Upgrade of the North Area's ECN3

by M. Fraser (CERN) on behalf of the PBC Study Group

There is strong and growing evidence from both particle physics and astrophysical observations for the existence of physics Beyond the Standard Model (BSM). Yet, so far it has evaded direct discovery in high-energy colliders. This calls for novel experiments that will increase the scope to search for new, low mass feebly interacting particles (FIPs) and to indirectly probe the multi-TeV domain beyond direct LHC reach. High precision and high intensity are crucial tools in this endeavour. In this context, the CERN SPS complex provides a worldwide unique combination of high-energy beams up to 400 GeV, high intensity and high duty cycle.

The North 3 Experimental Cavern (ECN3) is an underground experimental cavern on the CERN Prévessin site. ECN3 currently hosts the NA62 experiment, with a physics programme devoted to ultra-rare kaon decays and searches for hidden particles that has been approved until Long Shutdown 3 (LS3). Several options are in competition to exploit the potential of a higher-intensity proton beam in ECN3 after LS3. Over recent years, the CERN Physics Beyond Colliders (PBC) study group has studied the required accelerator infrastructure and upgrades, the necessary detector R&D and construction work, the relevant schedules and the cost, as well as the physics potential at CERN and worldwide [1].

HIKE/SHADOWS combines an upgrade of NA62, named HIKE, to perform higher-precision measurements of rare kaon decays in two consecutive phases devoted to K+ and K0 beams respectively, with the possibility to take data in Beam Dump (BD) mode by closing a collimator, as is done by NA62, to look for FIPs. In the BD mode HIKE would be complemented by an off-axis detector, SHADOWS, to extend the acceptance at higher FIP masses and perform neutrino measurements. Alternatively, BDF/SHiP is the implementation in ECN3 of the SHiP detector and the associated Beam Dump Facility (BDF). The latter was initially proposed as a new underground complex, and can be realised in ECN3 with a significant cost reduction. BDF/SHiP is designed as a state-of-the-art beam dump experiment with a dual spectrometer for searches for FIPs and neutrino measurements. It has been slightly downsized compared to the former proposal in order to fit inside the ECN3 experimental hall, and has been brought closer to the proton beam dump to preserve the initial acceptance.

The PBC ECN3 Beam Delivery task force [2] concluded that a new high-intensity facility in ECN3 is feasible for operation starting in Run 4 with over, an order of magnitude increases in spill and yearly integrated intensity. The High Intensity ECN3 (HI-ECN3) upgrade project will benefit from working in synergy with the ongoing North Area consolidation project (NA-CONS). New transfer line optics combined with vertical magnetic bumps will be employed to bypass the existing beam intercepting devices that are used to split and share the beam with the existing production target systems, which were designed back in the 1970s. With the installation of a new high-power target system (> 100 kW average beam power) and a target complex that respects stringent modern-day radioprotection legislation and best practices, the requirements of all the letters of intent that have been received for the exploitation of ECN3 after LS3 can be satisfied without increasing dose rates. ECN3 can be decoupled from the rest of the North Area, allowing the upgrade work and experiment installation work to be completed in the first part of Run 4 without any impact on NA operation in the other two main experimental halls (EHN1/EHN2) and providing test beams for important detector R&D immediately after LS3. The cost of the HI-ECN3 upgrade project is estimated at 64 MCHF from today to 2031.

Based on the findings of the PBC ECN3 Beam Delivery Task Force and the experiment-independent recommendation for the intensity upgrade of ECN3 by the SPS and PS Experiments Committee (SPSC) in June 2023, the CERN Director-General allocated 2.5 MCHF to preliminary work in 2023 – 2024, pending the decision on the post-LS3 ECN3 experimental programme and official approval of the project. This approval should come well ahead of LS3 to allow timely implementation of the HI-ECN3 facility in Run 4 and to benefit from potential synergies with the NA-CONS project.

In the meantime, the ATS Director mandated the HI-ECN3 study project team to continue working in earnest on experiment-independent studies, further developing the beam delivery aspects and carrying out the pre-studies required to converge on a final technical design report (TDR) detailing the facility with a refined cost, resource and timeline breakdown before the end of 2025. This year, hydro-geological surveys were carried out in the North Area to better assess the design choices for civil engineering, and machine development studies were done to test a recently installed prototype magnetic bump system that allowed a low intensity proton beam to be diverted around the existing NA target complex and transferred to ECN3 on a dedicated cycle and without splitting.

An experiment-specific decision from the CERN Research Board before the end of 2023 will allow the detailed TDR study phase to start and the deadlines imposed by the NA-CONS project to be met before LS3, with the completion of the TDR expected by the end of 2025. On this timeline it is expected that the civil engineering can be completed in the first year after LS3, followed closely by installation and commissioning, culminating in first beam in ECN3 in 2030.

References:

[1] Post-LS3 Experimental Options in ECN3, CERN-PBC-REPORT-2023-003, CERN, Geneva, Switzerland, 2023, https://cds.cern.ch/record/2867743.

[2] Findings of the Physics Beyond Colliders ECN3 Beam Delivery Task Force, CERN-PBC-REPORT-2023-001, CERN, Geneva, Switzerland, 2023, https://cds.cern.ch/record/2847433.

HIKE

by C. Lazzeroni (University of Birmingham)

The High-Intensity-Kaon-Experiments (HIKE) project represents a broad, long-term programme that will take place at CERN after Long Shutdown 3 (LS3). Based in the North Area ECN3 experimental hall, it will cover all the main aspects of rare kaon decays and searches accessible via kaon physics, from ultra-rare kaon decays to precision measurements and searches for new phenomena. The HIKE collaboration is formed of 195 participants from 42 institutions, with a very strong presence from Europe, and submitted a proposal to CERN in October 2023 (**CERN-SPSC-2023-031; SPSC-P-368**). HIKE is intended to continue the very successful tradition of kaon experiments at CERN in ECN3, where NA62, currently operating, is the latest of these experiments. The continuing experimental interest in the kaon sector derives from the possibility of conducting precision measurements, particularly of suppressed or rare processes, which may reveal the effects of new physics with mass-scale sensitivity exceeding that which can be explored directly, e.g. at the LHC or a next-generation hadron collider. Continuation of high-intensity kaon experiments at CERN was identified as an essential scientific activity in the 2020 update of the European Strategy for Particle Physics and is strongly supported in the national roadmaps across Europe. Because of the relatively small number of kaon decay modes and the relatively simple final states, combined with the relative ease of producing intense kaon beams, kaon decay experiments are in many ways the quintessential intensity-frontier experiments.

The primary goals of HIKE are to probe the Standard Model (SM) with kaon decays at the $O(10^{-13})$ level in terms of decay branching fractions; to improve the precision of rare kaon decay measurements to the level needed to match or challenge theory; to measure for the first time channels not yet observed; to search with unprecedented sensitivity for kaon decays forbidden by the SM; and to explore BSM parameter spaces never investigated before. HIKE will also address beam-dump physics in regions of mass–coupling space complementary to those for other existing and planned experiments. The breadth and depth of the HIKE physics programme is unique, bringing the kaon and long-lived feebly-interacting-particle (FIP) programmes to a new level of precision.

HIKE will take advantage of a beam intensity of up to six times higher than that of NA62 and of cutting-edge detector technologies to perform precision measurements and searches. This will allow HIKE to play a pivotal role in the quest for BSM physics at the sensitivity required by the present experimental limits and theoretical models, over a wide range of possible masses and interaction couplings.

The HIKE programme is organised into phases, with first installation and commissioning anticipated in 2030. HIKE implementation will follow a general, staged approach, in which new or refurbished detectors are installed as soon as they are needed and ready, while maintaining the principle that changes must serve the remaining phases of the programme once they are applied. The organisation into phases will allow insertion, repositioning or removal of specific elements, depending on the physics requirements, on top of a largely common detector and DAQ suitable for all phases. The changes required between phases mainly concern the beamline.

Phase 1 will make use of a K^+ beam with an intensity of four times that of NA62. The centrepiece of the programme is the measurement of $B(K^+ \to \pi^+\nu\nu)$ to $O(5\%)$ precision, approaching the unreducible theoretical uncertainty, in four years of data taking. This golden-mode combines an extreme SM suppression and theoretical cleanness with high sensitivity to a variety of new physics models. A broad array of measurements will also be carried out using the intense beam and state-of-the-art detector. Phase 2 will make use of a K_L beam with an intensity of six times that of NA62. The main goals are the measurement of the $Br(K_L \to \pi^0 e^+ e^-)$ and $Br(K_L \to \pi^0 \mu^+ \mu^-)$ with 20% precision in five years of data taking; these decays are sensitive probes for new physics that has never been observed before and constrain the CKM unitary triangle. A broad slate of other K_L decay measurements is similarly planned. HIKE will also run periodically in beam-dump mode to perform searches for FIPs. The physics programme is summarised in Table 1.

$K^+ \to \pi^+ \nu\bar{\nu}$	$\sigma_{\mathcal{B}}/\mathcal{B} \sim 5\%$	BSM physics, LFUV
$K^+ \to \pi^+ \ell^+ \ell^-$	Sub-% precision on form-factors	LFUV
$K^+ \to \pi^- \ell^+ \ell^+$, $K^+ \to \pi\mu e$	Sensitivity $O(10^{-13})$	LFV / LNV
Semileptonic K^+ decays	$\sigma_{\mathcal{B}}/\mathcal{B} \sim 0.1\%$	V_{us}, CKM unitarity
$R_K = \mathcal{B}(K^+ \to e^+\nu)/\mathcal{B}(K^+ \to \mu^+\nu)$	$\sigma(R_K)/R_K \sim O(0.1\%)$	LFUV
Ancillary K^+ decays (e.g. $K^+ \to \pi^+\gamma\gamma$, $K^+ \to \pi^+\pi^0 e^+ e^-$)	% – ‰	Chiral parameters (LECs)
$K_L \to \pi^0 \ell^+ \ell^-$	$\sigma_{\mathcal{B}}/\mathcal{B} < 20\%$	Imλ_t to 20% precision, BSM physics, LFUV
$K_L \to \mu^+\mu^-$	$\sigma_{\mathcal{B}}/\mathcal{B} \sim 1\%$	Ancillary for $K \to \mu\mu$ physics
$K_L \to \pi^0(\pi^0)\mu^\pm e^\mp$	Sensitivity $O(10^{-12})$	LFV
Semileptonic K_L decays	$\sigma_{\mathcal{B}}/\mathcal{B} \sim 0.1\%$	V_{us}, CKM unitarity
Ancillary K_L decays (e.g. $K_L \to \gamma\gamma$, $K_L \to \pi^0\gamma\gamma$)	% – ‰	Chiral parameters (LECs), SM $K_L \to \mu\mu$, $K_L \to \pi^0\ell^+\ell^-$ rates
Search for FIPs in kaon and dump mode	Sensitivity $O(10^{-5})$ - $O(10^{-10})$	BC1,2,4,5,6,7,8,9,10,11

Table 1: summary of the HIKE physics programme

The possibility to measure Br($K_L \to \pi^0\nu\nu$) in a third longer-term phase demonstrates that HIKE will continue to be able to produce extremely interesting measurements over an even longer period of time.

While the conceptual layout is based on the successful one of NA62, new detectors will replace those of NA62 with the goal of improving the performance and sustaining higher rates. The prime examples are the beam tracker, the straw spectrometer and the particle identification system, the development of which related to the goals of ECFA DRD Working Groups 3,1 and 4 respectively.

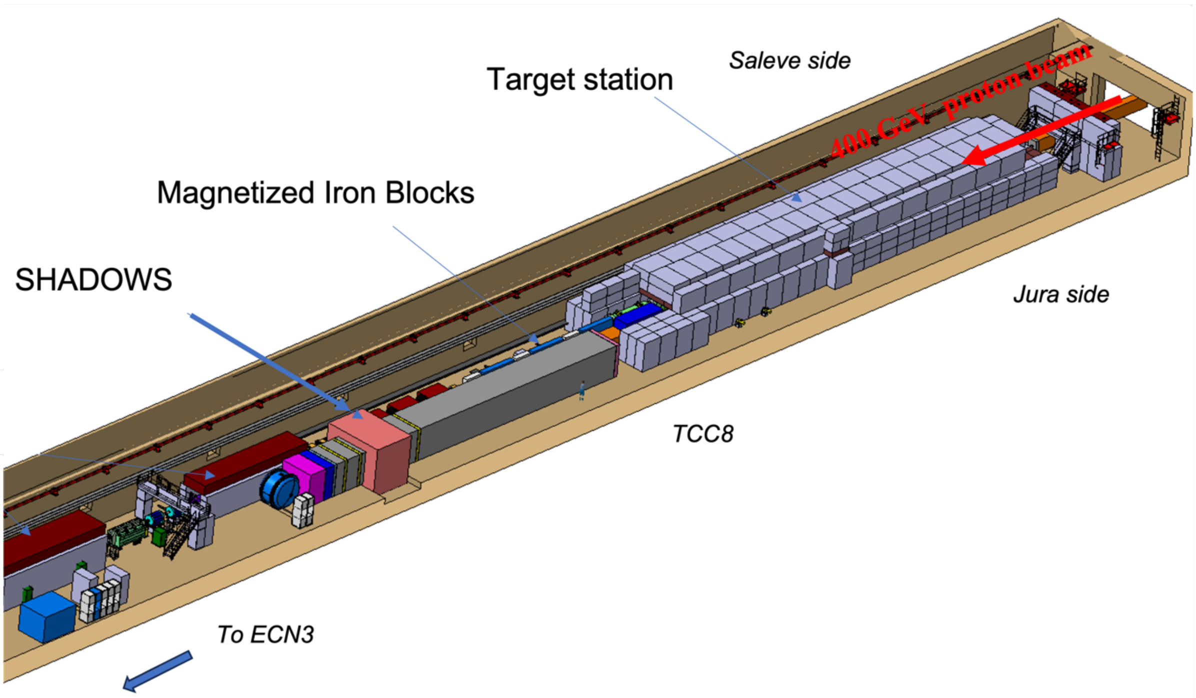
Phase 2 will use an experimental set-up with minimal modifications with respect to the first phase. The EM calorimeter for the neutral phase must be able to operate in an environment with intense soft-photon and neutron fluxes, the development of which relates to the goals of ECFA DRD Working Groups 6 and 7. The basic technologies for HIKE detectors all exist already or prototypes are anticipated in the very near future. The detectors are challenging but smaller in size or quantity compared to many other experiments. Several detector developments have synergies with ongoing developments for the High-Luminosity LHC (HL-LHC) experiments.

Precision measurements of two of the quintessential golden modes, $K^+ \to \pi^+\nu\nu$ and $K_L \to \pi^0\ell^+\ell^-$, are at the centre of the HIKE programme. Measurements of the branching ratios and spectra of these decays offer model-independent standard candles that can constrain any BSM scenarios, present or future. The status of BSM models in the future is hard to predict, but measurements made by the unrivalled HIKE experimental programme will be durable standards against which many of those models will be judged. Presently, the main limitation to the investigation of BSM models, and more generally to the quest for new physics with kaons, comes from the limited statistical precision in the kaon decay measurements. Nonetheless, the HIKE measurements are a set of firm deliverables even if BSM does not manifest itself. HIKE is the only experiment worldwide where the wide-ranging programme described in this proposal can be addressed comprehensively.

SHADOWS: a new proposal to explore the Dark Universe

by G. Lanfranchi (INFN)

SHADOWS (Search for Hidden And Dark Objects With the SPS) is a proposal [1] for a new experiment to search for a large variety of feebly interacting particles (FIPs) possibly produced in the interactions of a 400 GeV proton beam with a dump.



SHADOWS in the TCC8/ECN3 area

In recent years, the physics of feebly interacting particles (FIPs) has received considerable and growing attention from the broad HEP community [2], motivated by both existing data and by the appeal of simple extensions of the Standard Model to address long-standing puzzles in which FIPs play an important role. These puzzles include the baryon asymmetry of the Universe, the nature of dark matter, the origin of neutrino masses and oscillations, cosmological inflation, the strong CP problem and the hierarchy of scales. The importance of FIP searches has been clearly stated by the recent recommendations of the European Strategy for Particle Physics update, which includes the physics of FIPs among the essential particle physics activities to be pursued in the next decade.

SHADOWS aims to be a main player in the search for FIPs with masses in the range of familiar matter, from the MeV scale to the scale of a few GeV. It will exploit the upgraded infrastructure and accelerator complex in the ECN3/TCC8 experimental area, which will be consolidated and upgraded during the next long shutdown (LS3). It aims to take data concurrently with HIKE [3], NA62's successor, when the beamline is operated in beam-dump mode by taking data "off-axis" and integrating 5×10^{19} protons on target in about four years of data taking.

The young collaboration, today comprising about 80 scientists from 16 different institutions, has almost tripled in the mere 20 months that separate the submission of the expression of interest to the SPSC in January 2022 and the submission of the technical proposal in October 2023. This rapid expansion shows the profound interest of the community in FIPs and the appeal for the new generations of a medium-sized experiment with a short timescale. The technical proposal has been scrutinised by the SPSC and a decision on the project's approval is expected by December this year. If approved, SHADOWS aims to start taking data in 2030.

The SHADOWS + HIKE system will allow a broad exploration of the hidden sector below and above the kaon mass, complementing the excellent flavour programme pursued by HIKE on its own. The possibility of exploring new light and feebly interacting phenomena and, simultaneously, very high-scale masses through precision measurements in the kaon sector makes the combined SHADOWS + HIKE system unique worldwide.

In addition to the FIP programme, a compelling neutrino programme can be pursued with NaNu (North Area NeUtrino detector), a SHADOWS sub-detector dedicated to neutrino physics. NaNu could perform the first observation of the τ anti-neutrino, the only particles of the Standard Model for which a direct observation is still missing, and precise measurements of neutrino cross-sections in a phase space complementary to the one explored at the SND@LHC and FASER experiments currently running at the LHC.

The upgrade in intensity of the P42 beamline will provide CERN with a world-class facility, with several experiments running concurrently and covering a broad spectrum of very diverse physics topics, which is crucial, we think, for the future of particle physics.

References:

[1] SHADOWS Technical Proposal, SHADOWS coll., CERN-SPSC-2023-029; SPSC-P-367.

[2] Feebly Interacting Particles: FIPs 2022 workshop report, A. Antel et al., arXiv : 2305.01715 [hep-ph]

[3] High Intensity Kaon Experiments (HIKE) at the CERN SPS: Proposal for Phase 1 and 2, The HIKE coll., arXiv:2311.08231, CERN-SPSC-2023-031; SPSC-P-368.

SHIP

by R. Jacobsson (CERN) on behalf of the BDF/SHiP Collaboration

The BDF/SHiP collaboration has proposed a general-purpose intensity-frontier experimental facility ([1] [2] and references therein) operating in beam-dump mode at the CERN SPS accelerator to search for light dark matter (LDM) and associated mediators, as well as the origin of neutrino mass generation. The project has been demonstrated to enable a generic exploration of feebly interacting particles (FIPs), of hidden sector models and other Standard Model (SM) extensions with masses up to 5 GeV/c^2 [3]. The proposal is the result of the collaboration's initiative to seek returning the SPS to full physics exploitation with the 4×10^{19} protons per year at 400 GeV that became available after the termination of the CNGS project, and at the same time taking advantage of the ongoing ambitious consolidation of the experiment infrastructure at CERN's North Area. The high energy and intensity of the SPS, dumped on a thick high-A/Z target, gives access to unprecedented yields of charmed hadrons, annually ten times the yield at the HL-LHC, as well as to very large yields of B hadrons and electromagnetic processes, all of which are possible sources of a wide spectrum of FIPs. With the production modes confined to a relatively small forward solid angle, SHiP is able to provide efficient acceptance for the long lifetimes that are endemic to the region of the parameter space that is characterised by light FIPs and feeble couplings. This puts CERN and the SPS in a unique position worldwide to make a mark in the theoretically and experimentally attractive "heavy-flavour region", as a complement to the LHC and future colliders that are suited to covering the region of higher masses and shorter lifetimes in decays of heavy bosons.

SHiP's search strategy consists of deploying the two complementary techniques of detecting decay signatures in a large decay volume and scattering signatures against atomic electrons and nuclei in a heavy medium. Both detector set-ups have undergone a common background and acceptance optimisation. The

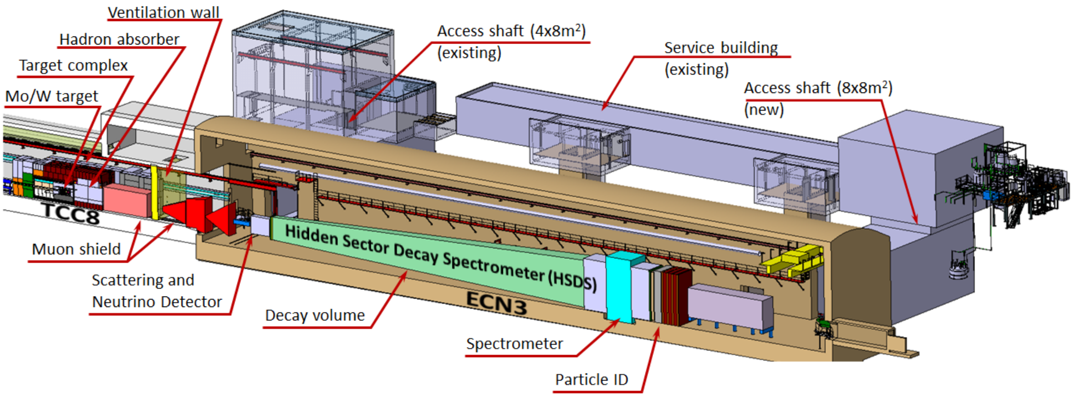


Figure 1: Overview of the BDF/SHiP experimental set-up in the SPS TCC8/ECN3 beam facility.

detector systems are designed to be as model-independent as possible, with full reconstruction and identification of as many final states as possible of both fully and partially reconstructible modes, in order to provide a generic discovery potential with a sufficient number of events to make precise measurements. The large production of neutrinos in the dump, in particular tau (anti) neutrinos from the D_s mesons, also makes SHiP particularly suitable for studying neutrino interactions of all neutrino flavours.

The BDF/SHiP experimental set-up at the ECN3 experimental facility (Fig. 1) consists of a high- density proton target, followed by a magnetic muon shield that deflects the beam-induced muons away from the detector acceptance. Upstream, the SHiP detector is composed of the Scattering and Neutrino Detector

(SND), which is designed to search for LDM scattering and perform measurements in neutrino physics. Downstream, the Hidden Sector Decay Search (HSDS) detector is designed to reconstruct the decay vertices of FIPs, measuring invariant mass and providing particle identification. All of SHiP's detector systems have undergone first-level prototyping and measurements with the prototypes in test beam, and the critical systems have already been tested using large-scale prototypes. The experiment optimisation and the evaluation of the physics performance have been studied with the complete experimental set-up implemented in simulation. The simulation has been tuned with the detector responses that have been measured with the prototypes in test beams. A dedicated measurement campaign with a full prototype of the SHIP target was also performed in 2018 to validate the muon spectrum obtained from the simulation. The principal emphasis of SHiP's experiment optimisation is the reduction of the flux of beam-induced muons and neutrinos through the design of the target, the muon shield and the low air pressure in the decay volume. The suppression of physics background from the residual muons and neutrinos relies critically on the veto systems surrounding the decay volume, and on kinematics and time coincidence. Invariant mass and particle identification are not used in the signal selection. This ensures model independence and the possibility of measuring the background with data by relaxing the different suppression techniques. In this way, SHiP has demonstrated that it is capable of reducing the background in the decay search to well below one event in 6×10^{20} protons on target, equivalent to 15 years of operation.

With a sensitivity that is not limited by background up to 6×10^{20} protons on target, SHiP has sensitivities to FIPs that are orders of magnitude better than competing projects in the complete spectrum of FIPs that are accessible through heavy flavour decays and electromagnetic processes. Quantitatively, SHiP is capable of exploring the convolution of 2-5 orders of magnitude in the square of the coupling strength and 1-2 orders of magnitude in mass beyond current experiments in all benchmark models. With the number of signal events expected in a significant part of the unexplored parameter space, SHiP is not only capable of characterising a new object in terms of its precise mass, decay branching ratios, spin, etc., but also of discriminating between models and, more importantly, testing the compatibility with models that are formulated to address a certain fundamental SM issue.

In the LDM search via scattering, the signal is characterised by an electron-induced shower with no other activity at the vertex. With the expectation of ~600 irreducible background events from neutrino elastic and quasi-elastic scattering in the 6×10^{20} protons on target, SHiP's direct search technique is nevertheless capable of reaching the expected limit from the relic density of dark matter in the mass range from 10 to 100 MeV/c2 ($m_X/m_{A'} = 1/3'$, $\alpha_D = 0.1$).

In neutrino physics, SHiP is both capable of performing SM tests and making measurements that contribute to improving knowledge of systematic uncertainties at other experiments. Annually, SHiP expects to reconstruct ~3500 tau (anti) neutrinos, among which the charge of the muon from the tau lepton decay makes it possible to distinguish between neutrino/anti-neutrino in ~500 events per year, and ~2×10^5 and $\sim 7\times10^5$ electron and muon (anti)neutrinos, respectively. This makes it possible to access the kinematic features of neutrino interactions and measurements with a statistical accuracy of below one percent. The principal source of systematics will come from the knowledge of the neutrino flux. SHiP aims at determining the flux of tau neutrinos to 5% and of electron and muon neutrinos to 5-10%. With this information, SHiP can provide relevant measurements of neutrino cross-sections up to 100 GeV, all lepton flavour ratios, and the *F4* and *F5* structure functions in the charged-current deep inelastic scattering cross-section that is only accessible with tau neutrinos, etc. Taking advantage of the large sample of neutrino-induced charm production, SHiP can improve on the knowledge of the nucleon strangeness and the CKM element $|V_{cd}|$.

SHiP's window of opportunity is linked to the unique situation at the CERN accelerator complex and the possibility of operating BDF/SHiP in synergy with all existing facilities. Thanks to the development work done on BDF/SHiP during the Technical Proposal and Comprehensive Design Study phases, Technical Design reports could be delivered in about three years' time, followed by a start of construction during CERN's Long Shutdown 3, with the aim of commissioning the facility and detector in 2031 and having at least one year of operation before Long Shutdown 4. During the operational life of BDF/SHiP, the facility and accelerator schedule offer opportunities for several attractive extensions that can be considered in the future, such as the use of a LAr TPC to extend SHiP's physics programme with a different technology, a synergistic tau flavour violation experiment, and exploitation of the secondary mixed-field radiation from the proton target for nuclear and astrophysics, as well as for materials testing.

References:

[1] SHiPCollaboration,BDF/SHiPattheECN3high-intensitybeamfacility-Proposal,CERN-SPSC- 2023-033 / SPSC-P-369.

[2] SHiP Collaboration, BDF/SHiP at the ECN3 high-intensity beam facility - Letter of Intent, CERN-SPSC-2022-032 / SPSC-I-258.

[3] S. Alekhin et al., "A facility to Search for Hidden Particles at the CERN SPS: the SHiP physics case", Rept. Prog. Phys. 79 (2016), no. 12 124201, [arXiv:1504.04855].

Plenary ECFA Meeting Reports

The ECFA Early-Career Researchers Panel

by A. Ilg (University of Zürich)

The ECFA Early-Career Researchers (ECR) panel is currently compiling its yearly report, which will be made available on arXiv towards the beginning of 2024 as was done for the reports for the years 2021 and2022 (see arXiv:2212.11238). An update of the panel's activities since the last newsletter are presented in this article.

The Career Prospects and Diversity in the Physics Programme working groups (WGs) are analysing the results of their survey, with the goal of releasing a report in early 2024. An excerpt of the results was presented in the last ECFA newsletter and at the last plenary ECFA meeting, highlighting the respondents' lack of information on topics such as funding opportunities, dissatisfaction with some aspects of work-life balance and the importance of a good working environment.
The second WG is dedicated to software and machine learning for instrumentation, and is actively engaging in the preparation of a comprehensive survey aimed at better understanding the needs and challenges of the community. The overarching objective is to gather valuable insights that will not only serve as constructive feedback for existing schools on instrumentation but also play a central role in potentially designing a new school (focusing on open source software, data acquisition and detector control systems).

The last WG of the ECFA ECR panel, named the "Future Colliders WG", is devoted to the future of HEP. This WG organised the Future Colliders for Early-Career Researchers event[1], which took place on 27 September and attracted more than a hundred in-person participants and many more online. All the slides and recordings are available and can serve as a reference tool for everyone interested in future colliders. The event introduced the various future collider proposals and the challenges associated with them. There was also a session on different viewpoints (low energy, astroparticle, etc.) and on the important non-scientific implications (careers, sustainability and socio-economic benefits) of future colliders.

Lively discussions were held on the timescales of the various future collider proposals and during the poster session, which showcased the work of ECRs on future colliders. A quick survey was performed both

[1] The organisers thank the CERN Council and TH secretariats for the catering and organisational assistance.

at CERN and during the workshop. The answers showed that many ECRs are already involved in the work on future colliders and that they consider this to be beneficial to their careers. A timely decision on future colliders is important as a majority of ECRs state that such a decision should be taken before or with the next update of the European Strategy for Particle Physics. The great passion for future colliders is reflected in the fact that most respondents would, however, still be prepared to work nearly full time on future collider-related projects if the decision on the next machine were still pending. A last conclusion from the short survey is that ECRs are perceived not to be sufficiently involved in the process of deciding on the next accelerator. Our WG will try to address this issue. In 2024, we will initiate ECR meetings in the ECFA member countries and at CERN, with the aim of advancing the discussions and addressing region-specific aspects.

Finally, representatives of the ECR panel were invited to attend the ICFA Seminar at DESY on future perspectives in high-energy physics. Our RECFA representative, Lydia Brenner, presented our panel to our worldwide colleagues, focusing on the perspectives of ECRs regarding the future of our field.

The Future Colliders for Early-Career Researchers event.

Mid-term Report from Poland

by J. Lagoda (National Centre for Nuclear Research, Poland)

Particle physics is present in several cities in Poland, the largest centres being Warsaw and Kraków. The main funding comes from the Ministry of Education and Science, which covers contributions to the international research infrastructures and maintenance and operation costs for most large experiment groups involved in CERN and non-CERN projects. The other important source of financing is the National Science Centre, which has a programme of grants that are available to scientists at different stages of their careers.

Poland has been a Member State of CERN since 1991 and has about 300 users and 90 staff members. The Polish contribution to the CERN budget is around 3% (approx. 36 MCHF in 2023). The industrial return factor is 0.74, which places Poland among the "poorly balanced countries"; however, the return in terms of staff and fellow selections is very satisfactory and amounts to 1.21 and 2.61, respectively.

Polish groups are involved in all four large LHC experiments, contributing to the hardware (upgrade), operation and physics analyses. In addition, Poland makes significant contributions to NA61/SHINE and COMPASS/AMBER at the SPS, the AD/ELENA experiments and various projects at the ISOLDE facility. Smaller groups are also participating in other CERN projects.

As for HEP outside CERN, the largest group is involved in ongoing and future neutrino experiments located in Japan. Smaller teams are taking part in projects related to the studies of high- and low-energy neutrinos and Dark Matter. Polish scientists are also active in flavour physics experiments in Japan and China. There is also growing interest in the EIC project in the US.

The Polish theory community has a broad and diverse programme of activities, is successful in obtaining additional funding and attracts a significant number of foreigner physicists.

The WLCG group provides reliable computing services for the LHC experiments, successfully fulfilling most of its pledges.

Since the RECFA visit in 2019, some progress has been made. The Polish Roadmap for Research Infrastructures has been established, and includes CERN activities, Hyper-Kamiokande and a number of astroparticle physics projects. However, there is still no clear funding path for detector R&D. More effort should also be made to attract students and coordinate outreach activities.

Report from Laboratori Nazionali di Frascati

by F. Bossi (LNF)

In 2023, both of the acceleration facilities of the INFN Laboratori Nazionali di Frascati (LNF) have operated at full efficiency.

The DAFNE collider has provided luminosity to the SIDDHARTA-2 experiment which aims at observing the formation of kaonic deuterium atoms for the first time. SIDDHARTA-2 requires a total integrated luminosity of 800 pb^{-1}; at present, the experiment has collected about half of this, so the completion of operations is planned for spring 2024. At the same time, the beam from the DAFNE LINAC has been delivered, parasitically, to the BTF test facility, for a total of more than 200 days.

After the first demonstration of lasing obtained by a plasma-accelerated electron beam [1], the SPARC_LAB accelerator has worked to consolidate this result, with a view to the construction of the EUPRAXIA@SPARC_LAB complex, which is expected to be ready by the end of the present decade. The project is set to go ahead on time; the authorisation to build has been issued by all the relevant national and local authorities, so that construction can start in 2024. Meanwhile, several fundamental sub-components of the machine are being tested in the lab, so far with encouraging results. Of relevance is the test of a 40 cm-long plasma capillary, the dimension required for EUPRAXIA operations.

Recently, the laboratory has entered into the exciting field of axion searches. A group of LNF scientists is planning the use of the cryogenic magnet of the FINUDA experiment to build a large haloscope sensitive to galactic axions in the 0.49 – 1.49 μeV mass range [2]. The magnet has not been in use for more than 15 years, so a refurbishment and reparation plan has been put in place to determine whether it can actually be used for the purpose. A crucial test is planned for the first months of 2024.

Figure 1: The Open Labs day

LNF scientists and technicians are involved in several construction projects for large experiments in external laboratories. The two most ambitious are participation in the construction of the ITK internal tracker of the ATLAS experiment for the HL-LHC, and the reuse of a large portion of the KLOE detector (which operated at DAFNE up to 2018) as a part of the near detector of the DUNE experiment at FERMILAB. Both projects will be an important commitment of the laboratory for a few years to come.

Since many years, LNF has followed the mission of spreading scientific culture to society. A large number of events, visits and seminars have been organised throughout the year, involving mainly students from the elementary level to high schools, but also people of every age interested in science. The most relevant of these events was the "Open Laboratory" day on 27 May, during which more than 2000 people visited the laboratory's infrastructure and participated in lectures, seminars and hands-on events. (see fig.1 above.)

[1] R. Pompili et al., Nature 605 (2022) 7911, 659-662

[2] D. Alesini et al., Phys.Dark Univ. 42 (2023) 101370

Report from Paul Scherrer Institute

by M. Seidel (PSI)

The Paul Scherrer Institute, PSI, is the largest research centre for natural and engineering sciences within Switzerland, with its research activities concentrated on four main subject areas: Future Technologies, Fundamentals of Nature, Energy and Climate, and Health Innovation. Researchers in Future Technologies and Fundamentals of Nature use particle accelerator facilities to study the properties of a wide range of materials and the internal structure of matter, from complex molecules to elementary particles.

Science with photons is conducted using a 2.4 GeV electron synchrotron SLS, serving 20 beamlines. Since October 2023, the operation of the synchrotron has been suspended in order to upgrade it with a completely new multi-bend achromatic lattice, which will increase the brilliance of the X-ray radiation by a factor of 35. The installation is expected to be completed by the end of 2024 and the machine will be back in operation by early 2025. An X-ray free electron laser consists of a 5.8 GeV high-brightness electron linear accelerator with two undulator beamlines and presents a pulsed X-ray light source, complementing the synchrotron at PSI. The megawatt-class high-intensity proton accelerator HIPA is used to generate high intensities of muons and neutrons serving 30 experiments and instruments at secondary beamlines. In addition, PSI operates a cancer therapy centre based on a 250 MeV proton accelerator with two gantries and a dedicated beamline for eye cancer treatment.

The particle physics programme at PSI [1] performs precision tests of the Standard Model using the HIPA facility. The upgrade project IMPACT for HIPA is scheduled for the period 2025-28. The aim is to install surface high-intensity muon beamlines (HIMB) with up to 1010 µ+/s, and a new facility for the production of large quantities of medical isotopes. The project will be the next major construction project at PSI after SLS2.0, and a conceptual design report [2] was completed in 2022. The new Mu3e experiment searches for the lepton flavour violating decay µ+ → e+e-e+ with an unprecedented sensitivity of 2×10-15, which can only be conducted at HIMB. The experiment uses new pixel detector technology, and first data taking is already planned for 2025 at an existing beamline. Another activity includes precision laser spectroscopy of light muonic atoms to determine their charge radii, most recently that of 3He. Another flagship particle physics experiment is the search for a neutron electric dipole moment using PSI's high-intensity source of ultracold neutrons. The n2EDM experiment implements very efficient magnetic shielding, which, combined with the high intensity, boosts the already leading sensitivity by a factor of 10. In addition to experiments at HIPA, PSI is also involved in the CMS experiment at the LHC and in a centre for Si pixel detector development.

PSI is the leading institute of the Swiss Accelerator Research and Technology Initiative CHART [1], a national collaboration involving PSI, ETHZ, EPFL, Uni Geneva and CERN to promote accelerator research for a next-generation collider at CERN. A major component of CHART is a high-field magnet programme that includes developments in both low-temperature and high-temperature (HTS) superconducting magnet technology. Another activity within CHART is the development of an injector concept for FCC-ee including a positron source with high positron yield, based on the use of an HTS capture solenoid. A proof of concept experiment for the positron source is planned at the SwissFEL linac. Other accelerator-related R&D activities at PSI include the development of high-brightness electron sources in close collaboration with INFN Italy.

References:

[1] https://scipost.org/SciPostPhysProc.5

[2] https://www.dora.lib4ri.ch/psi/islandora/object/psi:41209

[3] https://chart.ch/

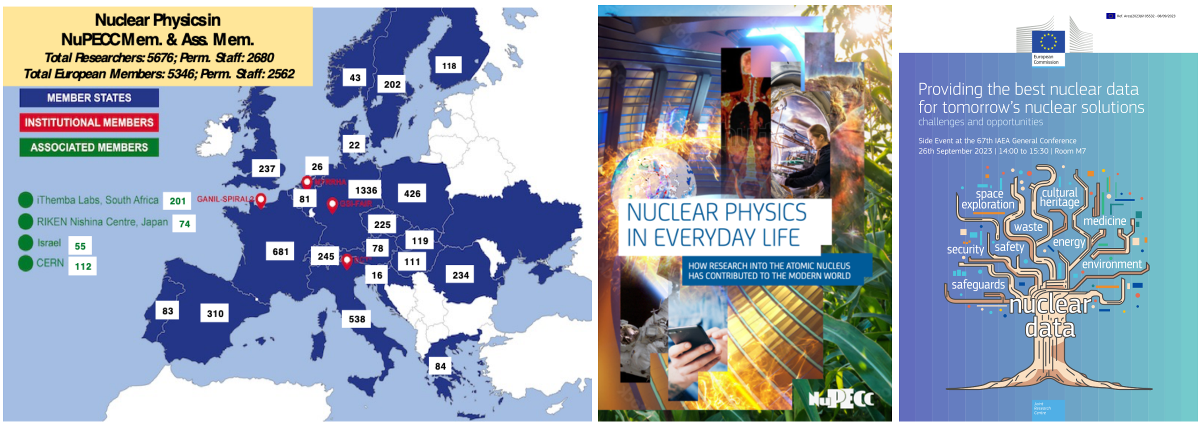
NuPECC activities and Long Range Plan 2024 for Nuclear Physics in Europe

by M. Lewitowicz (GANIL)

The Nuclear Physics European Collaboration Committee (NuPECC) hosted by the European Science Foundation, today represents a large nuclear physics community spanning 23 countries, 3 ESFRI (European Strategy Forum for Research Infrastructures) nuclear physics infrastructures and the ECT* (European Centre for Theoretical Studies in Nuclear Physics and Related Areas), as well as 4 associated members and 9 observers. Ukraine joined the Committee as a new member in May 2023.

- **Examples of recent NuPECC activities**

NuPECC, together with ECFA and APPEC, initiates, coordinates and actively participates in actions towards further development of the three disciplines in the framework of JENA. Recent initiatives for nuclear physics include a survey of nuclear physics human resources in Europe, the NuPECC report on Nuclear Physics in Everyday Life and joint NuPECC-IAEA actions on *Needs for a Comprehensive European Plan to Acquire and Curate Nuclear Data*. The latter resulted in a Summary Report of the IAEA Consultants' Meeting IAEA Headquarters, Vienna, Austria 25 – 27 April 2023 .



Examples of recent NuPECC activities

- **NuPECC 2024 Long Range Plan for Nuclear Physics in Europe**

As stated in the NuPECC terms of reference, one of the Committee's major objectives 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) for European nuclear physics".

To this end, NuPECC has produced five LRPs to date: in November 1991, December 1997, April 2004, December 2010 and November 2017. The LRP 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 in Europe. It also serves as a reference document for the strategic plans for nuclear physics in individual European countries.

In February 2022 NuPECC published an assessment of the implementation of the 2017 LRP, which summarises achievements in nuclear science and techniques resulting from the LRP recommendations.

At its meeting in Madrid in May 2022, NuPECC took the decision to launch the process of creating a new Long-Range Plan for Nuclear Physics in Europe with the aim of publishing the document in 2024.

With the intention of strengthening the bottom-up approach that has always played an important role in its LRPs, NuPECC has launched a call for contributions to the next LRP in the form of short documents describing the views of collaborations, experiments or communities on the key topics for the next 10 years to be included in the upcoming LRP. The Committee received 159 contributions submitted by the European nuclear physics community and several countries, as well as collaborations/projects from other continents. These contributions served as a solid background for the elaboration of detailed reports by 10 dedicated Thematic Working Groups (TWGs).

The whole process of elaborating the LRP2024 is supervised by a Steering Committee composed of recognised experts in different sub-fields of nuclear science and of representatives of major nuclear physics facilities. At the beginning of 2024, the Steering Committee, in collaboration with the TWG Conveners, will prepare a draft version of the LRP2024 recommendations, which will be presented at a dedicated Town Meeting in April 2024 and the subject of broad consultation with the European nuclear physics community. Publication of the final version of the LRP2024 is expected in the second half of 2024.