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European Committee for Future Accelerators

11th ECFA Newsletter

Following the 112th Plenary ECFA – EPS-HEP meeting
24 August 2023
https://indico.desy.de/event/34916/sessions/15178/#20230824

Summer 2023

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Introduction

After the endorsement of the implementation plan for the detector R&D roadmap by CERN Council in September 2022, the formation of Detector Research and Development collaborations (DRD collaborations) has very much progressed over the first half year of 2023. For five out of the six technology areas defined in the roadmap process, proposals were prepared by the interested communities and submitted for review to the newly formed Detector R&D Committee (DRDC) at CERN at the beginning of August. The review process is assisted by the ECFA Detector Panel (EDP), that will address i.a. whether the proposals meet the needs of the most urgent topics identified in the roadmap process. With establishing these DRD Collaborations at CERN a major strategic recommendation of the detector R&D roadmap process, to establish long-term strategic R&D programmes, will be achieved. Other strategic recommendation on the provision of R&D facilities, engineering and software support etc. are being addressed at present by a common working group of ECFA and the Lab Directors Group (LDG).

In the ECFA e+e- Higgs factory studies, important focus topics were investigated in preparation of the second ECFA workshop, which will take place in Paestum/Italy from 11 to 13 October 2023. We hope on a strong participation of both experimentalists and theorists in this workshop, which is essential to prepare the input to the next round of the European Strategy of Particle Physics, where a decision on the next large collider project must be taken.

In relation to the Joint ECFA-NuPECC-APPEC (JENA) activities, an important workshop on computing took place in Bologna in June. The workshop was attended by experts to explore whether synergies in computing between the three areas can be exploited. Such a workshop was initiated in discussions at the last JENA Seminar in Madrid in May 2022. The discussions at the workshop were very constructive and it was agreed to establish five working groups to further investigate the most relevant topics over the forthcoming years, with the goal to provide feedback to funding agencies at the next JENA Seminar in early 2025 as well as to strategy discussions in the three research areas.

Finally, the ECFA plenary session in summer 2023 took place during the EPS-HEP conference in Hamburg. In this newsletter you will find short reports on the presentations given there on the status of the implementation of the European Strategy update, covering the FCC Feasibility Study, more details on the formation of DRD collaborations and on the ECFA e+e- activities. In addition, the status in the various e+e- Higgs factory projects was summarised, and we heard an interesting talk on the activities of the ECFA Early Career Researches Panel (ECR). In this context, we would like to point to an important upcoming meeting on Future Colliders for early-career researchers that will take place at CERN on 27 September 2023. The aim of this one-day workshop is to introduce ECRs to the future collider proposals currently under consideration, so that young researchers can form their opinions about this important matter for their future and for the future of our field, and to foster the discussion within the ECR community on the same topic.


Karl Jakobs
ECFA Chair

Patricia Conde Muíño
ECFA Scientific Secretary

FCC Feasibility Study

by M. Benedikt, F. Zimmermann (CERN)

As reported previously (ECFA Newsletters #7, #8, #9 and #10), the Future Circular Collider (FCC) Feasibility Study (FS) was launched by the CERN Council (see CERN/3566 and CERN/3588) in response to the 2020 update of the European Strategy for Particle Physics (ESPP). The FCC FS is mandated to deliver a Feasibility Study Report (FSR) by the end of 2025. A “mid-term review” is scheduled for autumn 2023.

In early 2023, a lowest-risk implementation baseline was finalised, with a circumference of 90.7 km. Meetings have already been held with the 41 municipalities concerned in France and Switzerland (see fig. 1). Environmental studies and preparations for geological investigations (drillings and seismic investigations) have been under way since February 2023.

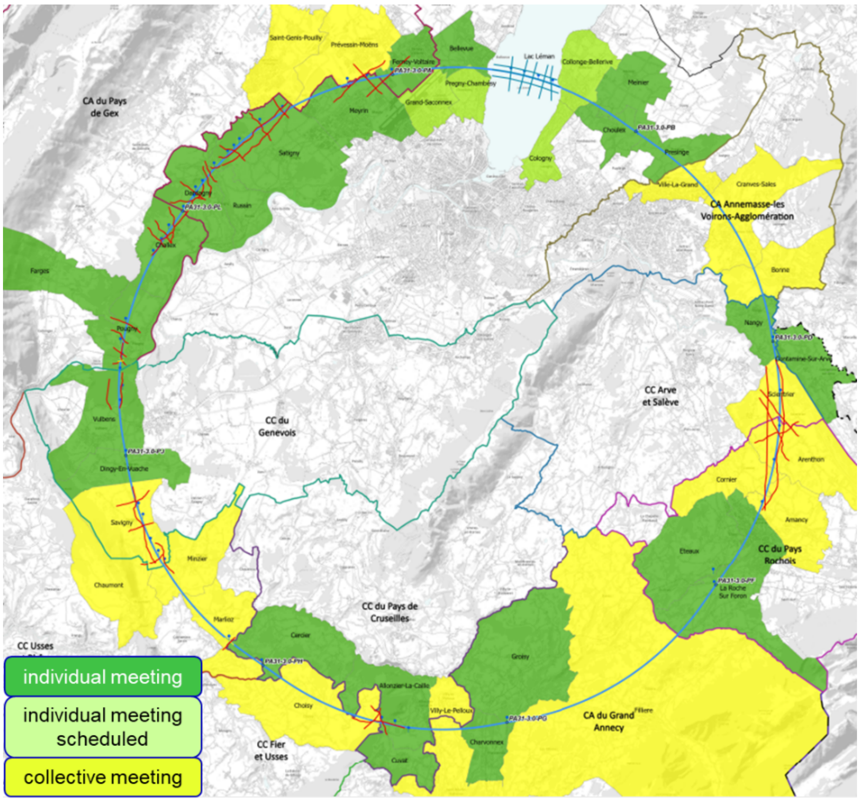


Figure 1: Meetings of the FCC study team with the municipalities concerned in France (31) and Switzerland (10).

A CERN press release issued in February 2023, which had been prepared together with the Swiss and French authorities, provided information about the Feasibility Study and its organisation. This was followed, in April, by a press visit at CERN for local media representatives. In total, 11 journalists participated in this visit, which resulted in 90 press clippings, not only in the local area, but in 31 countries.

An electrical powering concept for the FCC has been defined in collaboration with the French high-voltage electricity grid operator, RTE. Road accesses have been identified and documented for all eight surface sites. Four possible highway connections have been defined, which could be used for materials transport. The total length of new roads required at the departmental road level is less than 4 km.

The layout of the FCC-ee superconducting radiofrequency (RF) systems has been modified. The RF for the collider and the booster will now be installed in the separate straight sections H (collider) and L (booster), which will also have fully separated technical infrastructure systems, such as cryogenics. The collider RF, which has the highest power requirements, is now located at point H, ensuring an optimum connection to the existing 400 kV grid line and a more suitable surface site.

In addition to the baseline operation sequence starting on the Z pole, an alternative operation and RF staging sequence has been developed, which begins at the ZH production peak. Either sequence would extend over a total of 16 years, including, as the final stage, five years of $t\bar{t}$ operation.

In the framework of the Swiss CHART programme, an innovative idea is being pursued for the short straight sections in the FCC-ee arcs: PSI and CERN are jointly developing nested sextupole and quadrupole coils, made from high-temperature superconductors (HTS) and operating at around 40 K. A 1-m prototype will be manufactured by 2026. This scheme promises several important benefits, such as power saving, increased dipole filling factor and enhanced optics flexibility.

A siting study for the FCC-ee pre-injector on the CERN Prévessin site has been conducted, with a preliminary layout shown in fig. 2. There is sufficient space not only to house the 6-GeV linac and the damping ring, but also a higher-energy linac, accelerating electrons and positrons to an energy of 20 GeV.

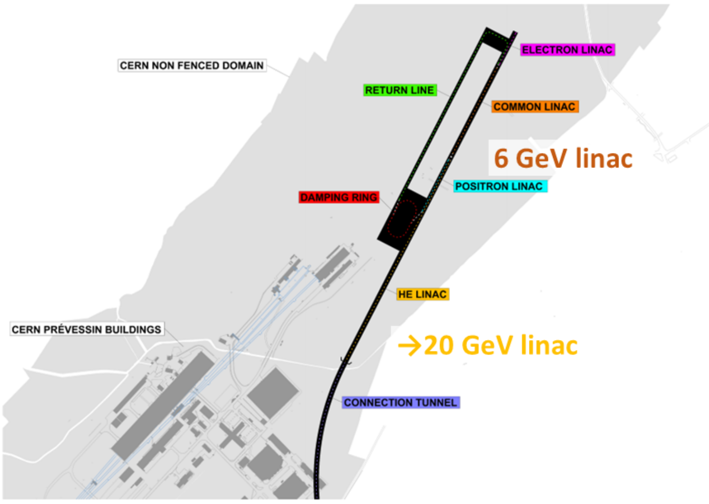


Figure 2: Basic and extended FCC-ee pre-injector complex located on the CERN Prévessin site.

FCC Week 2023 was held in early June. It attracted 473 expert participants, including a growing number of young scientists. London proved a highly appropriate place for many intriguing talks and discussions that significantly sharpened and cemented the case for the FCC, including talks by the CERN Director-General, Fabiola Gianotti, the CERN Council President, Eliezer Rabinovici, and the STFC Executive Chair, Mark Thomson.

The mid-term review will mark the completion of the first half of the FCC Feasibility Study. The review will address the following topics: infrastructure and placement; technical infrastructure; accelerator design for both the FCC-ee and the FCC-hh; physics, experiments and detectors; organisation and financing; environmental impact; socio-economic impact; and a cost update. September, October and November 2023 are likely to be busy months, not only for the FCC team but also for the reviewing bodies, namely the FCC Scientific Advisory Committee and the FCC Cost Review Panel.

Status of e+e- Higgs factory projects

by J. List (DESY)

In the last update of the European Strategy for Particle Physics, an e^+e^- collider serving as a Higgs factory was identified as the highest-priority next collider. Last year, this was re-emphasised in the final report of the Snowmass Community Study in the US, recognising that the Higgs boson is intimately connected to nearly all our fundamental questions about the origin and development of the Universe and that thus a significantly more precise characterisation of its properties and its potential is an essential ingredient in addressing these questions.

The status of the main e^+e^- Higgs factory projects, FCCee, CEPC, CLIC and ILC, as well as of more recent proposals like C3, was summarised during the ECFA plenary session at the EPS-HEP conference in Hamburg, following a series of recent dedicated workshops on these projects [1–4]. The newest kid on the block, the Hybrid Asymmetric Linear Higgs Factory, HALHF, which collides a high-energy, plasma- wakefield-accelerated electron beam with a lower-energy conventional positron beam, entered the stage only in April this year [5].

While all these proposals differ in the accelerating technology and the site-specific design, they fall into two basic categories: circular colliders and linear colliders, both with their own advantages. Circular colliders offer several interaction regions, very clean experimental conditions and very high luminosity and power-efficiency at their lower energy stages. Linear colliders have a smaller footprint, offer polarised beams and give high luminosity and power efficiency at high energies. Both also come with visions for the long-term future: circular facilities could host a proton-proton collider, while linear facilities could be upgraded in energy – either by extending the tunnel or by replacing the accelerating structures with advanced accelerator technologies.

Despite these different features, all the proposed projects perform surprisingly similarly with respect to the core Higgs factory programme, as shown in the most recent SMEFT evaluation performed for the Snowmass Community Study [6]: the Higgs boson's couplings to the Z and W , to gluons as well as to b quarks and τ leptons, will be constrained at the level of about a permille, and the couplings to c quarks and photons at the level of one percent. The most striking gain over the HL-LHC expectations, however, is that the absolute couplings become accessible without any assumptions for the total width or the absence of exotic decay modes. Thanks to the known initial-state four-momentum, e^+e^- colliders offer the unique possibility to detect $e^+e^- \to ZH$ events only via the recoil against the Z boson, independently of the decay modes of the Higgs boson, as illustrated by a simulated event display in figure 3. This model-independent determination of the absolute couplings represents a qualitative leap in understanding and in our ability to test extensions of the Standard Model.

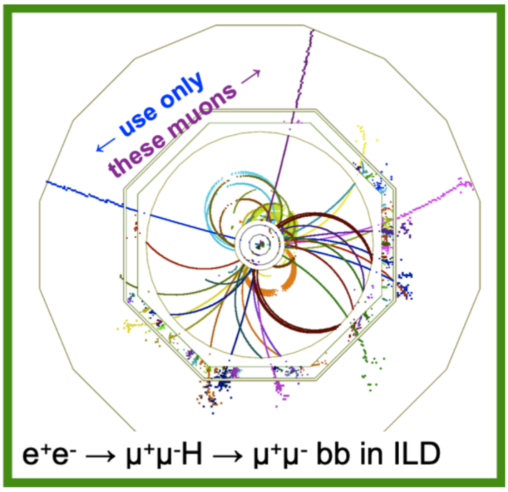


Figure 3: Event display of in the ILD detector.

Beyond the minimal Higgs programme, however, circular and linear colliders do place emphasis on different areas of physics. The very high luminosity of circular machines at the Z pole not only creates challenges for the detectors, but also offers a rich programme of physics at the intensity frontier, ranging from electroweak and QCD precision measurements to b- and τ-physics and searches for very light exotic particles. Linear colliders, on the other hand, offer a unique programme at higher centre-of-mass energies, comprising di-Higgs production, direct searches for new particles and a full precision programme for the top-quark, including the full CP structure of its electroweak and Yukawa couplings. A recent SMEFT fit of the top sector based on projections for the HL-LHC and various e^+e^- projects clearly showed that e+e− collisions at energies of 500 GeV and beyond with polarised beams are required in order to lift degeneracies between operators [7].

During the Snowmass process, a task force analysed the technical readiness, costs and timelines of the various proposed future projects [8]. The RF systems and the positron source were identified as critical components limiting the technological readiness level of the main Higgs factory contenders — and, at the same time, a lot of progress is being achieved in these areas: superconducting cavities with higher quality factors or higher gradients with simplified production recipes, higher-efficiency klystrons and positron sources with higher yield. And, very recently, CERN and KEK signed an agreement on the ILC Technology Network, which again features SCRF and positron source R&D as two major activities. In this network, CERN will act as a hub laboratory to facilitate the transfer of resources to other European laboratories and universities.

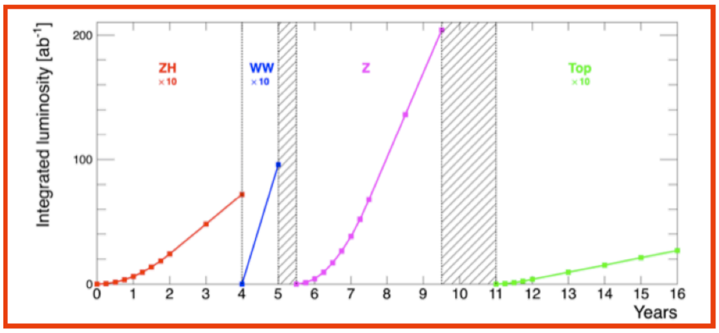


Figure 4: Alternative running scenario for FCCee starting with a Higgs run.

There are also new ideas on how to operate these machines: FCCee is now considering the possibility of starting operation with the Higgs physics run, as illustrated in Fig. 4 and later putting in the dedicated cavities for the high-luminosity run at the Z pole, which adds important flexibility to the running programme. CEPC is investigating the possibility of providing a longitudinally polarised electron beam to the experiments. Simulations show that when using a polarised source with $|P| > 85\%$, up to 70% transverse polarisation could be maintained through the booster ring and the top-up injection into the collider ring. The next steps will be to integrate spin rotators and polarimeters into the lattice.

When looking at the running scenarios for linear colliders, a peculiar situation can be found: While ILC historically picked 500 GeV, it has been known ever since the discovery of the Higgs boson at a mass of 125 GeV that this is slightly too low for an optimal study of $t\bar{t}H$ production. Therefore, C3 chose 550 GeV as the baseline, which immediately improves the projections for the achievable precision on the top Yukawa coupling by more than a factor of two. The CLIC running programme doesn't consider data taking in the range of 500 to 600 GeV at all, and instead proposes to jump directly from 380 GeV to 1.5 TeV. This seems to indicate an emerging need to re-discuss the optimal physics choice of energy stages beyond the Higgs run.

Last but not least, the particle physics community has realised that any future project needs to be designed and chosen taking into account its overall resource consumption and ecological footprint. A large share of the global warming potential (GWP) of future colliders is due to the construction of the tunnel, in particular the production of concrete and steel. As future circular colliders have a rather large circumference, the tunnel construction seems to dominate the GWP, while for linear colliders, which have a shorter footprint, the operation dominates [9]. On the positive side, a full life-cycle assessment according to ISO standards recently performed for CLIC and ILC [10] showed the potential to reduce the GWP of the construction by up to 40% by using low-CO_2 materials and by optimising wall thickness.

Realising the importance of sustainability considerations for future projects, the European Laboratory Directors Group recently established a task force to develop coherent criteria and guidelines for an assessment of new infrastructures. This group is expected to deliver a final set of standards by summer 2024, to be used by all proposals for the next update of the European Strategy for Particle Physics.

The approval of any new large-scale collider, however, requires a strong HEP community behind it, and excellent communication of the scientific case to experts from other fields, funding agencies and the general public, disseminated by a growing community of supporters. Thus: get engaged and make it happen!

References

[1] Linear Collider Workshop 2023, 15-19 May 2023, SLAC, US,

[2] FCC Week 2023, 5-9 June 2023, London, UK,

[3] CEPC Workshop 2023, 3-6 July 2023, Edinburgh, UK,

[4] C3 Workshop, 31 Aug - 1 Sep, U Cornell, US,

[5] B. Foster, R. D'Arcy and C. A. Lindstrom, doi:10.1088/1367-2630/acf395 [arXiv:2303.10150 [physics.acc-ph]].

[6] J. de Blas, Y. Du, C. Grojean, J. Gu, V. Miralles, M. E. Peskin, J. Tian, M. Vos and E. Vryonidou, [arXiv:2206.08326 [hep-ph]].

[7] G.Durieux,A.G.Camacho,L.Mantani,V.Miralles,M.M.López,M.LlácerMoreno,R.Poncelet, E. Vryonidou and M. Vos, [arXiv:2205.02140 [hep-ph]].

[8] T. Roser, R. Brinkmann, S. Cousineau, D. Denisov, S. Gessner, S. Gourlay, P. Lebrun, M. Narain, K. Oide and T. Raubenheimer, et al. JINST 18 (2023) no.05, P05018 doi:10.1088/1748- 0221/18/05/P05018 [arXiv:2208.06030 [physics.acc-ph]].

[9] M.Breidenbach, B.Bullard, E.A.Nanni, D.Ntounis and C.Vernieri,[arXiv:2307.04084 [hep-ex]].

[10] ARUP, CERN & KEK, *Lifecycle Assessment – Comparative environmental footprint for future linear colliders CLIC and ILC*

ECFA Study Towards a Higgs/EW/Top Factory

by G. Marchiori (APC, CNRS/IN2P3 and Université Paris-Cité, Paris)

The ECFA physics, experiment and detector (PED) 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. The ECFA PED study is designed to foster cooperation across the various projects, share challenges and expertise and explore synergies. The goals of the study are, among others: to encourage the consolidation, harmonisation, and expansion of the current physics studies; to favour the development of common tools that match the needs of the e+e− factory communities and that would lower the barrier for cross-project collaboration; and to create a forum for discussion between detector concept groups and detector R&D (DRD) teams in order to inform the R&D community about the needs of the future factories, to minimise duplication of work and to inject technological realism into conceptual detector studies. The activities are organised through three working groups: physics programme (WG1), physics analysis methods (WG2) and detector technologies (WG3). The progress of the lively ongoing programme can be followed on Indico. More details about the organisation of the study and the activities carried out during the first year are summarised in Ref. [1]. They are also described in Ref. [2], together with the activities of the second year. The latter are briefly summarised in this report.

WG1 is a forum on the physics potential of a future e+e− facility. It is divided into five sub-groups, each of which focuses on specific areas, such as Higgs, top and electroweak measurements, heavy flavour physics, direct searches for feebly interacting particles and low-mass resonances, precision calculations, and global interpretations using an effective field theory approach and their connection with complete models. During the second year, the working group has continued to organise topical meetings on these five areas – and has held a total of 13 since July 2022 – with the goal of mapping the landscape to be covered, collecting the results expected from other facilities prior to the operation of an e+e− factory and identifying areas that require specific efforts. In addition, it has organised bi-monthly seminars of general interest for a future e+e− factory.

More recently, the working group has begun to define a series of "focus studies" to be used by the whole community for various purposes, for instance to assess the ultimate potential of possible future projects, to estimate limiting factors for the detectors and obtain indications about the R&D that will be needed, and to steer theoretical/Monte Carlo (MC) work to support the feasibility of such studies and to obtain predictions whose uncertainties match the statistical precision of the measurements. A list of 15 focus topics has been drawn up, and a corresponding group of expert contact persons to steer the work is now in place. These contact persons are developing a detailed list of the work to be done and collating the material that is already available on each topic, with the aim of lowering the threshold for participation for newcomers and for members of other projects, to bring more people to work together cross-project. Each focus study will be officially launched with dedicated discussions at the next community-wide workshop in Paestum, in October 2023 [3].

The aim of WG2 is to trigger the development of algorithms and tools for MC event generation, detector simulation and event reconstruction, as well as to promote the integration of these algorithms and tools in a common software ecosystem. The working group's activities consist of topical and focus meetings. After an initial round of meetings during the first year, which were designed to take stock of the available tools and decide on the next actions, another round of meetings has been held in this second year to review progress and further discuss the future needs and developments. Here we list just a few of the highlights:

- A turnkey software stack, Key4hep, is being developed to provide a complete software ecosystem for HEP experiments. It encompasses models for data and detector geometry description and modules for integration of event generation, detector simulation, reconstruction, and analysis tools in a common framework. All proposed e+e− factory projects have migrated or are migrating their frameworks to Key4hep. This convergence process will make the tools developed for one project available to all projects, thereby enlarging the user base and thus ensuring better review and optimisation of the code, making cross-project collaboration easier and lowering the barrier for similar studies to be performed across different projects. In parallel, event generation, simulation and reconstruction tools and algorithms are maturing to become available to all experiments using Key4hep.

• A technical generator-benchmarking exercise has started. For each of more than ten MC generators an expert has been appointed as a contact person. The plan is to develop tools to provide automatic comparison of the generators for key processes at several centre-of-mass energies and to investigate any deviations with the MC experts, in order to identify and resolve issues or, where relevant, to quantify a generator-related uncertainty. The first results for fixed, leading-order predictions of selected differential distributions are expected by the time of the Paestum workshop.

• Progress is being made in preparing realistic luminosity spectra and momentum distributions of the initial state particles to take into account the effect of beamstrahlung in MC hard-process generators.

The goal of WG3 is to create a forum for the efficient and fruitful exchange of information and for the coordination of detector concept studies (within the various e+e− factory projects) and detector R&D (DRD) groups. The working group's activities started about one year later than the others, after the conclusion of the ECFA Detector Roadmap process, and are steered by the working group's conveners with the help of two scientists for each detector concept and DRD group. After initial discussions in the WG3 parallel sessions at the first ECFA workshop on e+e− factories in October 2022, two topical workshops took place in late spring 2023, one on calorimetry and particle identification and the other on vertexing and tracking. In the workshops, the experimental conditions and the constraints imposed on the experiment subsystems by the accelerators were reviewed, together with the performance needs imposed by the planned physics measurements. The working group has scrutinised the detector concepts that have been proposed to provide such a performance and has notably highlighted the related R&D challenges; it has also discussed the plans of the DRD groups for tackling these challenges. More topical workshops are planned, for example on trigger/data acquisition and on integration, mechanics, and cooling.

A few of the key take-home messages from the WG3 workshops are that vibrant detector concept and R&D communities are working together to overcome the technical challenges imposed by the accelerator constraints and the physics requirements of the e+e− factories, and that, although most of the proposed projects have been studied for up to a decade or even more, new ideas for detectors that could boost their performance and the ultimate sensitivity of their physics measurements are still emerging and being tackled by dedicated R&D work.

The activities of the three working groups will be discussed in the community-wide plenary workshop in October 2023, which will be a milestone of the ECFA study. The final goal is to release, by 2025, a written report to be submitted as major input for the next European Strategy update.

Acknowledgements

I would like to acknowledge the help and feedback of the PED study coordinators and working group conveners, as well as the dedicated work and fruitful discussions of the various subgroup conveners, contact persons and all participants in the PED initiatives.

References

[1] J. Alcaraz, G. Marchiori, F. Piccinini and A. Robson, ECFA studies towards a Higgs/EW/top factory, in 9th ECFA Newsletter (Summer 2022), https://ecfa.web.cern.ch/sites/default/files/ECFA%20Newsletter/202 09 Newsletter Summer Final.pdf

[2] G. Marchiori, *The ECFA study on future e^+e^- factories*, Presentation given at EPS-HEP2023, Hamburg (Germany), https://indico.desy.de/event/34916/contributions/142200

[3] Second ECFA Workshop on e^+e^- Higgs/EW/Top Factories, 11-13 October 2023, Paestum (Italy), https://agenda.infn.it/event/34841/

The ECFA Early-Career Researchers Panel

by A. Ilg (University of Zürich)

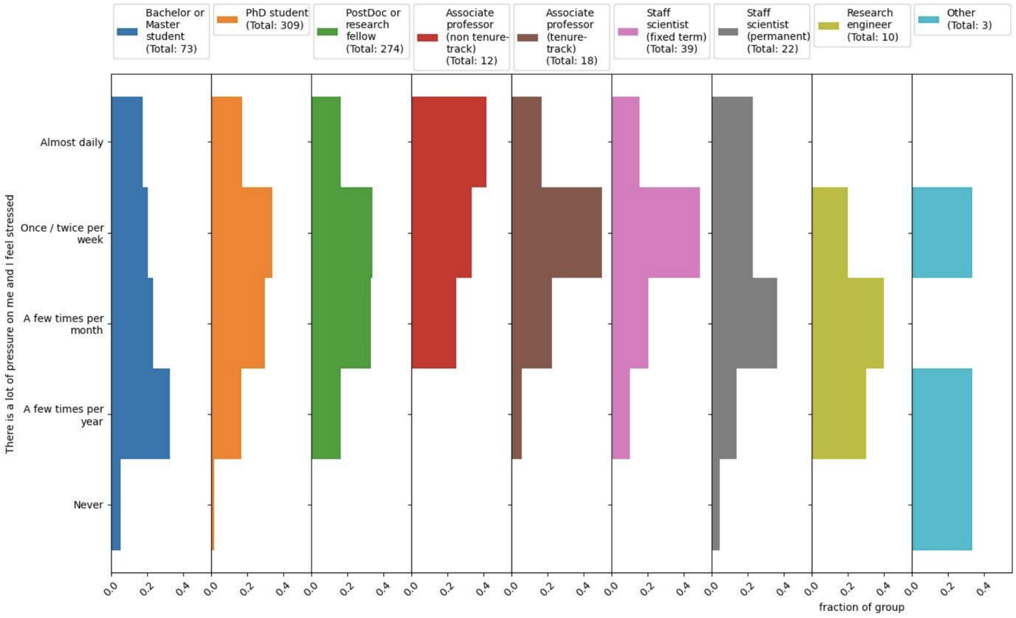
The ECFA Early-Career Researchers (ECR) panel has recently undergone a significant transformation. At the start of this year, some panel members completed their initial two-year term, while others embarked on a second term. Following this transition period, new ECR representatives took up their seats in Plenary ECFA and are guiding the panel's activities through the organising committee.

As the panel's final endeavour with its previous composition, it reflected on the achievements of the first two years of its existence. A comprehensive summary of these achievements was published on arXiv (arXiv:2212.11238).

A notable milestone of the panel's activities to date was the opportunity to present its work during the ECFA meeting at the EPS-HEP2023 conference recently held in Hamburg. In this talk, we recounted the panel's inception, following the update of the European Strategy for Particle Physics in 2020, and provided an overview of our past and present activities. One ongoing initiative carried over from last year involves a survey of career prospects and diversity in the physics programme in our field. In 2022, we collected data from a wide range of respondents, amassing a total of 760 responses from the ECR community and beyond. Once analysed, the results will be published on arXiv, as was the case with our previous survey on training in instrumentation (arXiv:2107.05739).

This year, we have established two new working groups. The first focuses on software and machine-learning applications in instrumentation. The second, in line with our panel's name, is designed to facilitate discussions about future colliders within the early-career researcher communities across Europe. Notably, this latter working group is organising an event entitled "Future Colliders for Early-Career Researchers", which will be held at CERN on 27 September and will also be accessible online (registration and abstract submissions for posters are still open). This event aims to introduce early-career researchers to the various future collider proposals and to foster discussions among them. We plan to follow up on this event by hosting ECR meetings in ECFA member countries, with the aim of advancing these discussions and addressing region-specific concerns.

Talk introducing the ECFA ECR panel at EPS-HEP2023.



Excerpt from ongoing analysis of career prospects and diversity in physics programme survey.

The ECFA Detector R&D Roadmap

by P. Allport (Birmingham) and D. Contardo (IP2I Lyon)

Forming Detector Research and Development (DRD) collaborations to execute the programme outlined in the ECFA detector R&D roadmap was endorsed by the CERN SPC and Council at their September 2022 meetings. The goals for the collaborations and the framework to host them at CERN were fully described in the document CERN/SPC/1190–CERN/3679 ("European Strategy for Particle Physics: Implementation of the Detector Research and Development Roadmap"). DRD collaboration activities will follow the general conditions of execution of experiments at CERN and will be reviewed by a dedicated Detector Research and Development Committee[1] chaired by T. Bergauer. The resource engagements of the participating funding agencies will be acknowledged by Memoranda of Understanding (MoUs) and their usage and evolution are planned to be reported at dedicated Research Review Board meetings. The role of the ECFA Detector Panel in this new framework was described in the SPC document and in the last ECFA newsletter. It will provide input[2] to the DRDC through the EDP co-chairs (as ex-officio members) and contribute to the reviews via cross-membership and invited experts.

The ECFA Roadmap Panel and task force teams were entrusted with preparing the DRD proposals. In this process, the leaders of ongoing R&D programmes (CERN RDs, CALICE, AIDAInnova, etc.) were naturally invited to facilitate the integration of existing communities and their activities into the new DRDs. The work started immediately in November 2022, with the target of obtaining approval by the CERN Research Board by the end of 2023, so that collaborations can become active by January 2024.

Five proposals and two Letters of Intent (LoI) have now been released to the DRDC and the review process is starting. The proposals concern "Gaseous Detectors" - DRD1, "Liquid Detectors" - DRD2, "Solid State Detectors" - DRD3, "Photon Detection and Particle Identification" - DRD4, and "Calorimetry" - DRD6. The LoIs concern "quantum sensors and emerging technologies" - DRD5 and "electronics and on-detector processing" - DRD7. The relevant communities were widely consulted in order to define the scientific programmes and to propose the subsequent organisation of work through dedicated workshops and surveys that collected input from the institutes wishing to contribute.

The documentation[3] outlines the programme for developing generic technical solutions, from the demonstration that they could be used for a strategic project[4] up to passing the developed technologies on to experiment collaborations for incorporation into their specific engineering designs[5]. Considering that the boundaries between strategic and experiment-specific R&D will continuously

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[1] The DRDC is composed of: Thomas Bergauer, HEPHY (chair), Sven Bentvelsen, NIKHEF, Shikma Bressler, Weisman Institute of Science, Dimitry Budker, Helmoltz institute Mainz, Roger Forty, CERN, Claudia Gemme ,INFN Genova, Ines Gil Botella, CIEMAT, Petra Merkel, Fermilab, Mark Pesaresi, Imperial College, Laurent Serin, IJCLab, ex-officio EDP chair.

[2] The EDP will assess the DRD proposals in terms of roadmap priorities; it will follow up R&D achievements and the developments of experiment concept groups in order to propose updates of the roadmap as needed.

[3] The documentation follows common guidelines proposed by the roadmap panel to define the expected content and ensure reasonably uniform material for the review process and to allow funding agencies to assess their contributions from a global perspective.

[4] The strategic projects were identified in the ESPP update of 2020.

[5] The DRD programmes cover roughly the range TRL3 to TRL6 in the language of the Technology Readiness Level model developed by NASA. The projects with a lower TRL are often referred to as "blue sky" R&D.

evolve, the proposals focus at this stage on a first R&D phase of about 3 to 4 years, to cover the needs of earlier strategic projects and to prepare the transition of technology towards longer-term needs[6].

The scientific programmes are broken down by technology areas[7] and developed via work packages that set out performance deliverables and milestones to be achieved in technology demonstrators and/or in system prototypes. An overview of the breakdown adopted in the different proposals was presented at the EPS-HEP 2023 conference at the Plenary ECFA session. The LoIs of DRD5 and DRD7 address their proposed broader scientific programmes, while the collaborations are still being formed. The DRD5 field is relatively new to HEP, verging on low TRL, but it has demonstrated capabilities to enter into specific strategic projects. This topic is also of worldwide societal interest in a competitive development environment with vast and very diverse funding sources. At this stage, the DRD5 team is focusing on identifying development areas where the HEP collaborative model could apply. DRD7 has strong interfaces to all other DRDs which will require cross-contributions that can now be established given knowledge of their proposed programmes. Both DRD5 and DRD7 are considering a network/hub organisation model with pools built around teams with identified competences and/or technical goals. They will continue to consult the community during the autumn and submit full proposals at the end of 2023 or early in 2024. The opportunity for an "integration" DRD8 collaboration covering detector mechanical structures, system integration and cooling devices is still being investigated with the relevant communities.

The DRD proposals also contain an evaluation of the manpower and funding needed to execute the work packages, together with a list of institutes wishing to contribute[8]. This assessment is backed up by a survey of available and requested resources, which was provided confidentially to the DRDC to allow it to evaluate the feasibility of the proposed programmes.

While the review process continues, the DRD collaborations will now form collaboration boards comprising representatives of contributing institutes to prepare their organisational structure and fill the positions within it. The resource MoUs for the first phase of the programmes will be prepared for release to funding agencies in 2024.

The ECFA roadmap implementation work will continue in order to address the other General Strategic Recommendations (GSRs) of the ECFA detector R&D roadmap, e.g. on infrastructure and training, involving the Laboratory Directors Group (LDG) and the ECFA Training Panel.

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[6] In its custodial role of the ECFA roadmap, the EDP will carefully monitor progress to ensure that opportunities will not be missed at one end, and that the detector R&D will not become a primary driver of the strategic project schedules at the other end.

[7] Depending on the specific DRD circumstances, technology areas can comprise independent developments of sensitive, readout, structure or services components, and/or their association up to a full detector prototype.

[8] DRD1 received preliminary proposals from 118 institutes in 30 countries, it was 114 institutes in 15 countries for DRD2, 100 institutes in 30 countries for DRD3, 64 institutes in 19 countries for DRD4, 110 institutes in 25 countries for DRD6, 40 institutes in 15 countries for DRD5 and 50 institutes in 18 countries for DRD7

Plenary ECFA meeting reports

Report from CERN

by J. Mnich (CERN)

In 2023 the LHC successfully restarted, with first beams achieved at the end of March. During the spring the accelerator performed outstandingly well, with a new record pp luminosity of 1.2 fb^{-1} delivered within 24 hours to both ATLAS and CMS. Despite an unscheduled interruption of five days due to a faulty RF finger module, the integrated pp luminosity delivered to each of the two experiments up to mid-July amounted to around 32 fb^{-1}. Unfortunately, on 17 July, a fault on an external power line caused several magnets to quench. This is not unusual, but this time it resulted in a leak of helium into the insulation vacuum of the final focus magnets left of point 8, where the LHCb experiment is located. The leak was pinpointed in the interconnect between two quadrupoles, and the repair work, including a warm-up and cool-down cycle, took several weeks. All efforts were made to allow the LHC to be restarted in September, ready for the scheduled heavy ion programme.

The LHC detectors are in good shape and performing very well, with the important exception of the LHCb VELO subdetector. On 10 January 2023 an incident occurred due to a failure of the VELO's vacuum system. While the detector modules and cooling system are not damaged, the RF foils separating the primary vacuum from the secondary vacuum have undergone significant deformation. A tomography scan performed using the first high-intensity collision data from 2023 allowed the deformation to be imaged and led to the conclusion that the VELO must remain open during the entire 2023 run. The RF foils will be replaced during the 2023/24 Year-End Technical Stop, and the impact on the LHCb's physics reach in 2023 is under study.

Very good progress has been made on the Nb_3Sn magnets for the new inner triplet systems for the HL-LHC. Seven of the sixteen 4.2 m-long MQXFA magnets to be supplied by the US have been accepted after reaching the nominal current plus a 300 A margin at 1.9 K. Two of these magnets make up a cold mass assembly, the first of which has been tested successfully. The MQXFB programme at CERN has also made significant progress. Magnets have been tested at the nominal current plus a 300 A margin without showing any degradation after several thermal cycles. In summary, the Nb_3Sn HL-LHC triplet quadrupole magnets are on track for the start of series production.

Good progress has also been achieved with respect to the Phase II upgrades of ATLAS and CMS, which are now moving from the R&D phase to the pre-production phase. An example is the CMS Barrel Timing Layer (BTL), where unexpected light loss and a higher dark current rate (DCR) after irradiation were observed last year, which would lead to a significant degradation of the timing resolution during HL-LHC operation. Optimisation of the configuration allowed almost the full $\sigma(t)$ performance to be recovered, as demonstrated by the latest test beam studies. The BTL prototyping phase is now complete and CMS is ready to start procurement. Another positive achievement is the completion of the production of the ATLAS small-diameter monitored drift-tube (sMDT), where the expected single tube detection efficiency of 99% and the 5 μm wire positioning accuracy were achieved.

However, challenges remain as some sub-detectors have continued to accumulate delays and are now very close to the critical path. The contributions expected from institutes in Russia and Belarus will have to be covered by other partners and funding agencies and this has not yet been fully achieved. Given the importance of maintaining the schedule and starting HL-LHC operation in 2029, greater engagement by all members of the collaborations is required. With the help of external consultants, plans are being developed to speed up the production phase in order to regain contingency in the schedule of the most critical sub-detectors.

To fully exploit the HL-LHC for heavy ion and flavour physics, ALICE and LHCb are planning to install upgrades during the 2033-2034 Long Shutdown (LS4). The LHCC has started the review process for both projects, and discussions with funding agencies are ongoing. The LHCC expects to receive scoping documents describing different upgrade scenarios early in 2024, together with the estimated costs and physics performance. An important criterion for the approval of these projects will be their compatibility with the available financial and human resources and the HL-LHC schedule.

This year's FCC week took place in London from 5 to 9 June. It was a very intense and productive meeting, which attracted 473 participants, most of them attending in person. One of the major recent achievements of the FCC Feasibility Study is the optimisation of the ring placement. The layout, shown in figure 5, has been chosen from around 100 initial variants, based on geology and surface constraints as well as on environmental and infrastructure considerations. The FCC ring will have a circumference of 90.7 km, eight surface areas, a four-fold super-periodicity and the possibility of two or four interaction points.

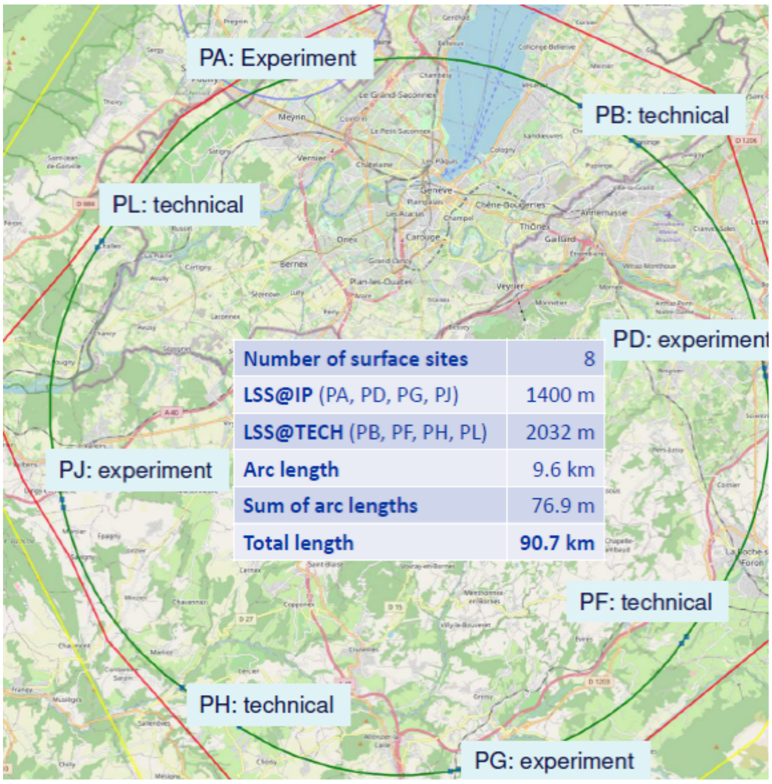


Figure 5: Layout of the 90.7 km FCC ring resulting from the optimization process.

The FCC Feasibility Study, which started in 2021, will be the subject of a mid-term review at the end of this year and will be completed in 2025 with a report as input for the next update of the European Strategy. It will cover the integrated programme, with FCC-ee first, followed by FCC-hh. Considering the potential timeline for approval by the CERN Council, CERN's experience in building colliders and the fact that the HL-LHC will run until 2041 to deliver 3000 fb^{-1} to ATLAS and CMS, a realistic start date for FCC-ee physics exploitation is around 2045.

The study of a potential upgrade of the North Area with a higher-intensity beamline has progressed and a task force has provided a preliminary cost estimate. A decision on this upgrade is expected in early 2024, such that the main work required can be carried out during LS3. The SPSC is performing an evaluation of two possible experimental programmes, namely very rare kaon decays (HIKE with SHADOWS as an off-axis beam-dump detector) or a dedicated beam dump experiment (SHiP), with the goal of making a recommendation by the end of 2023.

In the neutrino physics domain, CERN is continuing the two main activities for the LBNF/DUNE project. The first is to validate the final prototypes of the DUNE far detectors, i.e. the horizontal and the vertical drift concepts, at the CERN Neutrino Platform (NP). Unfortunately, the progress here is still hampered by the lack of liquid argon at a reasonable cost. However, the aim is still to close the two NP cryostats this year, ready for test-beam campaigns in 2024. The second main activity is the construction of two large cryostats (≈ 66×18×19 m^3) for the DUNE far detectors. This project is advancing very well: for example, pre-assembly of the outer warm steel structure of the first cryostat is in progress.

The Science Gateway is nearing completion, and the official inauguration is scheduled for 7 October 2023, when an event attended by high-level invitees will take place. The first scientific symposium is scheduled for 31 October 2023, to celebrate the 50th anniversary of the discovery of neutral currents and the 40th anniversary of the first observations of the W and Z bosons.

News from the European labs

Signature of two collaboration agreements between CEA-IRFU and CERN for the High-Field Magnet project

By F. Sabatié (IRFU)

François Jacq (CEA — Chairman), Fabiola Gianotti (CERN — Director-General) at the signing of the HFM-Nb_3Sn collaboration agreement. (credit: Cavazza Marina / CERN)

The last update of the European Strategy for Particle Physics recommended a feasibility study for the future generation of colliders. In this context, the Laboratory Directors Group has been mandated by the CERN Council to oversee the development of an accelerator R&D roadmap. One of the objectives of this roadmap is the development of technologies for high-field superconducting magnets, which will be essential for the future collider: this is the High-Field Magnet (HFM) project.

In this framework, IRFU has proposed to develop high-magnetic-field magnets using two generations of superconductors: Nb_3Sn, a low-temperature superconductor, and ReBCO (rare-earth barium copper oxide), a high-temperature superconductor (HTS). Accordingly, two collaboration agreements between CEA-IRFU and CERN have been signed. The HFM-Nb_3Sn agreement was signed by CERN Director-General Fabiola Gianotti and CEA Chairman François Jacq at a ceremony held at CERN on 23 March 2023. The aim of this work package is to develop and validate the various technological stages, up to the manufacturing and testing, of a model magnet generating up to 16T and representative of an accelerator magnet. The HFM-HTS work package was signed in June 2023, and its aim is to develop and test new technological concepts for reaching 16 T and above, up to the manufacturing and testing of an HTS model coil.

News from DESY

By B. Heinemann and T. Schörner (DESY)

ALPS II has started data taking

On 24 May 2023, the ALPS II experiment celebrated the start of data taking (see figure 6; figure 7 shows a view of the central optics breadboard). A smooth data run was performed in May and June, with an initial configuration without the resonating cavity on the axion production side. Since then, the collaboration has been working on the optimisation of the configuration and the automation of data taking in order to achieve an integrated amount of one million seconds of good data. These data will form the basis for a first physics publication on axion searches with ALPS II. The sensitivity on the axion-photon coupling is expected to be increased by a factor 100 with respect to previous experiments. In 2024, the entire optics system will be installed, leading to a further improvement of the sensitivity by a factor of 10.

Figure 6 On 24 May 2023, the ALPS II magnets reached full current for the first physics run (credit: DESY).

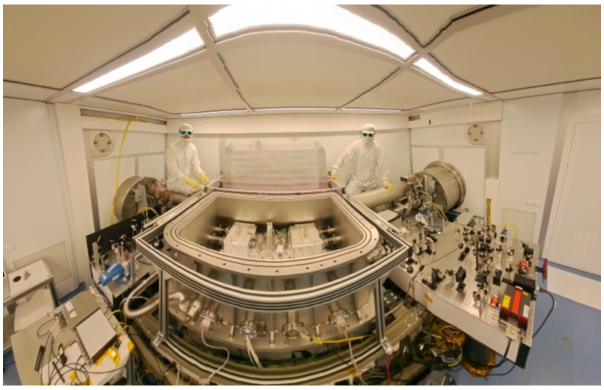


Figure 7 The central optical breadboard of the ALPS II experiment (credit: DESY).

The Belle II pixel-vertex detector, commissioned and tested at DESY, is expected to start collecting data in early 2024

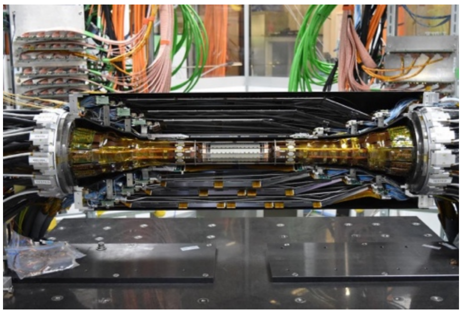


Figure 8 The PXD2 installed inside the Belle II experiment (credit: KEK)

The new Belle II pixel-vertex detector PXD2 was shipped from DESY – where it had been assembled and pre-commissioned – to its final destination at KEK in March 2023. The detector, which is about the size of a soda can, has since been successfully installed inside the Belle II experiment at the SuperKEKB collider (see figure 8). It will be commissioned in the coming months, in order to be ready for data taking in early 2024. For more details, please refer to the article at interactions.org.

HALHF accelerator concept

DESY scientists Brian Foster and Richard d'Arcy, together with Carl Lindstrom (Oslo), have devised a new concept for a linear Higgs factory, called "HALHF" ("hybrid, asymmetric, linear Higgs factory") [1]. The concept involves a 500 GeV electron beam accelerated by a beam-driven plasma *wakefield accelerator, and a 31 GeV positron beam accelerated by a conventional accelerator (see figure 5). This design choice was made to reach a centre-of-mass energy of 250 GeV using plasma acceleration only for electrons as the R&D required for positron acceleration is much less advanced. It is planned to develop this concept further to see if it could be a cost-effective alternative to other ideas.*

[1] B. Foster et al., arXiv:2303.10150

Highlights from IJCLab – autumn 2023

by A. Stocchi (IJCLab)

The following report gives some brief news about recent achievements in accelerator and particle physics experiments at IJCLab.

- ThomX (a new-generation compact Compton source at Orsay) received the first X-rays at the end of June, with a measured flux of 5.8 106 ph/s. Correction of the electrons' orbit and the use of full laser power will allow a higher flux to be achieved. The facility has recently been authorised to send X-rays to the experimental area, opening up the possibility for the first experiments to be performed at the beginning of 2024.

- Within the PALLAS project we have developed a new plasma target for localised ionisation injection; first electron bunches have been accelerated in the energy range of 150- 600 MeV.

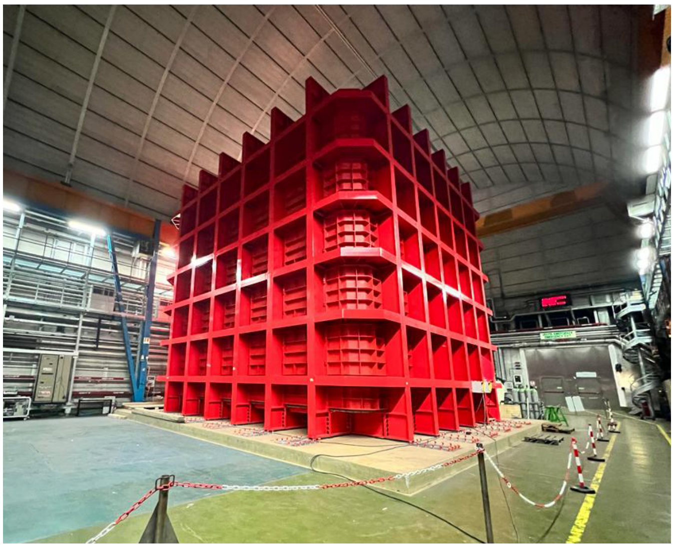
- At IJCLab we are operating the MOSAIC platform, a multidisciplinary ion beam facility for the synthesis, modification and characterisation of materials and biological specimens, and interactions. The platform includes two electrostatic accelerators (2 MV ARAMIS and 4 MV Andromède), ion implanters operating in a range from 190 kV IRMA to 400KV, a 40kV mass spectrometer, several characterisation instruments (SEM-EDX, AFM) and a 200 kV in situ TEM (transmission electron microscope). More information can be found at this link.

- Another new platform (PSI) has been constructed and is fully operational for detector characterisations and production for the ITK-ATLAS experiment. This platform will be also used for the HGTD-ATLAS experiment and for EIC.

- IJCLab recently joined the DUNE collaboration and is carrying out substantial work at CERN on the installation of the Module-0 vertical drift. We are also contributing to the PIP II project, and the first two prototypes of the SSR2 (Single Spoke Resonators type 2) cavities have been validated and largely exceed the project specifications in terms of acceleration.

Highlights from the Gran Sasso National Laboratory - INFN

by R. Antollini (LNGS)



The cryostat structure of the DarkSide 20k experiment – Gran Sasso National Laboratory -INFN

In the last few months the commissioning of the 3.5 MV singletron™ accelerator within the Bellotti ion beam facility has been completed. On 19 June the data collection for the first physics run began and the first measurement campaign will run until February 2024. Activities for the ERC Starting Grants are also involved in this first phase of measurements. As from next October it will be possible to apply for beamtime at the Bellotti IBF's 3.5 MV Singletron. More information is available on the IOB facility webpage.

The installation of the DarkSide 20k dark matter experiment is ongoing and the cryostat structure is being assembled in the underground hall C. The construction of the cryostat and the cryogenic facilities will be completed in 2024 in order to prepare for the installation of the TPC detector in 2025.

The external area of the Gran Sasso National Laboratory hosts the NOA facility (Nuova Officina Assergi), a new industrial research infrastructure for the assembly and testing of silicon devices. At present, NOA is working on the innovative photodetector for the DarkSide 20k experiment, which is based on SiPM-devices: several dozen square meters of SiPM will be analysed and assembled in a suitable package. The facility, which has become an integral part of the Gran Sasso National Laboratory, is fully operational and represents an advanced technological hub for companies and research institutes.

Preliminary data collected by the LEGEND 200 experiment on the search for neutrinoless double beta decay during five months of running with 140 kg of 76Ge detectors were presented at the TAUP conference. These results confirm expectations for the experiment's functionality and performances as well as for the background noise reduction. Early next year the installation of ultrapure germanium crystals is expected to be completed and the first results for neutrinoless double beta decay are expected in 2024.

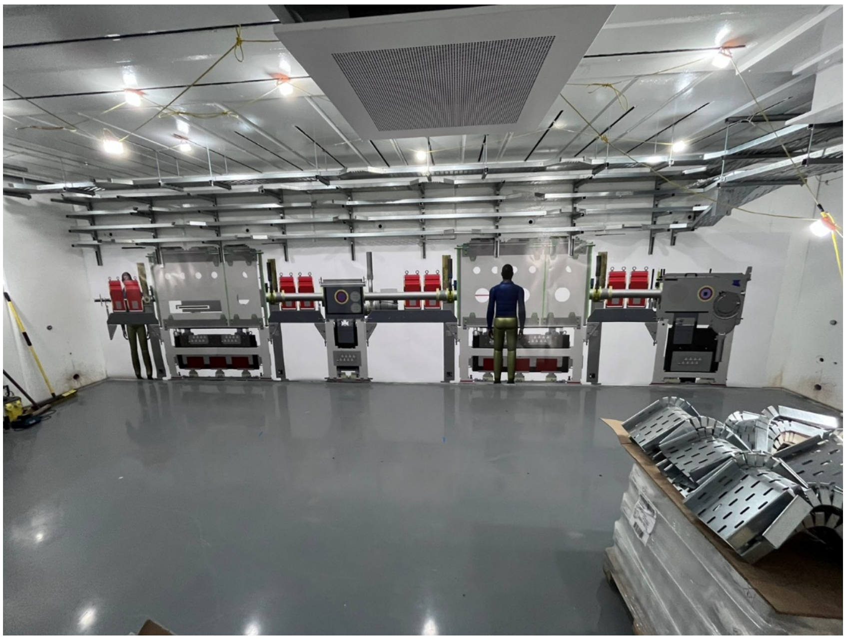
News from the CLARA facility at the STFC Daresbury Laboratory

by J. Clarke (STFC)

The Compact Linear Accelerator for Research and Applications (CLARA) is an advanced electron accelerator test facility at the Daresbury Laboratory. CLARA's major objectives are to be the European test bed for accelerator research and development, to enable the UK's academic, industrial and health sectors to develop new accelerator-based technologies and to pave the way for the UK to build a next-generation X-ray free-electron laser user facility.

The CLARA front end delivered 35 MeV high-brightness electron beams for nine user experiments from October 2021 to April 2022. An extremely diverse programme of research was carried out covering areas such as alternative acceleration techniques (laser-induced plasma wakefield, dielectric wakefield and THz-based), novel diagnostics and detector development, medical physics and radiation biology. As in the previous run (2018-2019), the beamtime requests were oversubscribed by a factor of two and included a number of users through the Horizon 2020 ARIES Trans-National Access programme.

Our in-house-designed high-repetition-rate photoinjector was successfully commissioned in March 2023, and will provide an ultrabright beam at the CLARA specification of 100 Hz. In parallel to the CLARA user programme, followed by gun commissioning, we have been constructing the modules to build the next phase of CLARA, which will increase the beam energy to 250 MeV. These modules were built off-line and tested fully before being moved to and installed in the shielded accelerator area. Installation and commissioning of RF systems on the roof of the accelerator hall has been ongoing in parallel. Since April 2023, CLARA has been in shutdown to complete this upgrade, which includes a dedicated full energy beam exploitation beamline (FEBE) transporting 250 MeV, 250 pC high-brightness beam at a 100 Hz repetition rate into a separately shielded enclosure.



FEBE hutch showing layout of the beamline. Beam from right to left, with laser mirror box to bring in the 100 TW class laser co-linear with the electron beam, first experimental chamber, laser mirror box to dump the laser, and second experimental chamber. The spectrometer dipole is installed in the main accelerator hall.

The FEBE beamline includes two separate experimental chambers, which will allow users to bring their experiments built on breadboards to be installed easily. The beam line includes a comprehensive set of beam diagnostics and the flexibility to carry out a wide range of experiments with easy access to the hutch without switching off the accelerator. Following the successful beam delivery and high-impact publications from the CLARA front end, STFC has funded a 100 TW class laser which will allow ambitious proof-of-principle experiments combining the CLARA electron beam with this laser in the FEBE hutch. The commissioning of the technical systems of the accelerator will start towards the end of this year, and will be followed by beam and laser commissioning. We expect that the user exploitation programme will start in early 2025 following a kick-off meeting with potential users in autumn 2024. We are looking forward to making CLARA a unique facility for users in Europe and invite interested users to get in touch with deepa.angal-kalinin@stfc.ac.uk.

CLARA upgrade installation showing part of linac and beamline including variable bunch compressor dipoles (in blue) at the far end.