

Midterm Review of the European Accelerator R&D Roadmap

The European Accelerator R&D Roadmap with five topical R&D panels was implemented in 2022, following a recommendation of the 2020 update of the European Strategy for Particle Physics Update (ESPPU) to intensify the accelerator R&D. This first phase of the accelerator roadmap is planned till 2026. In February 2025 a mid-term review of the roadmap activities has been conducted on behalf of LDG, by an independent panel of experts. The review assesses the status of the R&D activities, the readiness of the involved technologies and the future plans. In this submission to the ESPPU we motivate this review of the European Accelerator Roadmap and publish the report of the review committee.

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Introduction to the Accelerator Roadmap and the mid-term Review

The European accelerator R&D Roadmap [1] was established following recommendations by the European Strategy for Particle Physics Update (ESPPU, [2]) in 2020. The roadmap comprises five R&D panels. Two of them cover technologies: a program for High Field Magnet (HFM) developments for a future hadron collider, and one on RF systems including RF sources, superconducting and normal conducting accelerator structures. The other three programs are covering advanced concepts: plasma wakefield acceleration, muon colliders and energy recovery linacs. These concepts have potential advantages over the classical collider concepts, but they are associated with a need for significant R&D as well as with increased complexity. Launched in 2022 the first phase of the roadmap will conclude in 2026.

In February 2025 a comprehensive review of the R&D was performed on behalf of LDG. The objective was to assess progress against initial plans, the maturity of key technologies and future plans. The review committee was charged with these questions:

1. In relation to the goals and objectives of the 2022 Accelerator R&D Roadmap, is the progress and current status of R&D appropriate?
2. Are the plans for the remainder of the R&D period from 2025-26 adequate and have necessary decisions been taken to set priorities?
3. Are the current organisational structures for R&D effective?
4. Has the readiness of the core technologies been correctly assessed at present and at an appropriate future date relevant to the application?
5. Are the plans presented by the panels for future topics and the next stages of R&D appropriate and effective?

In addition to the answers to these questions, the committee concludes with findings, comments and a concise set of recommendations. Two members of the expert review committee were assigned with each R&D panel. They met several times before the actual review meeting at CERN with the members of their assigned panels to discuss the criteria of the assessment and the content to be presented. We are publishing the report of the review committee chaired by Norbert Holtkamp of Stanford University as an annex to this contribution to the update of the European Strategy for Particle Physics, and the executive summary is also reproduced in this document.

LDG will use the comments and recommendations of the review to guide the future programme of the Accelerator Roadmap.

Executive Summary of the Review Committee (cited from report)

From its inception the Accelerator R&D Roadmap was an ambitious enterprise taking a broad look at technologies as well as facility related developments that support ambitious plans for High Energy Physics. In 2022 the roadmap was published and approved by the CERN in March of 2023. It was developed under the auspices of the Laboratory Directors Group (LDG) and as part of the European Strategy Update¹. This review is a midterm review of the program which presently is scheduled to finish by the end of 2026.

The Accelerator R&D Roadmap is a tremendous opportunity to collaborate and coordinate among the European laboratories and help shape the future of High Energy Physics. It brings together expertise from European laboratories not only to commonly developed technology and advance HEP facility plans but also communicate what technologies can realistically be deployed on what time scales as well as what resources are necessary to get to that point.

The three facility pillars of the roadmap provide exciting visions for future HEP infrastructures (Plasma Wakefield Accelerators (PWAs), Muon beams and Energy Recovery Linacs (ERLs)). The two technology pillars (High Field Magnets and High Gradient Structures and Subsystems) provide essential building blocks; including for the Future Circular Collider (FCC) and Linear Colliders (LCs).

In several cases this program has been instrumental in receiving additional funding, but it did not receive the resources backing everything in the approved plan. All the pillars will need funding to continue beyond 2026, some of them significantly more to advance.

The review team tried to get a better understanding of the framework under which the Accelerator Platform leaders and coordinators were to operate. It would be a great benefit to the program if the LDG would clarify the mission of the Accelerator Platform and the roles and responsibilities of the leaders that were asked to coordinate them. The mission could be more direct coordination or focus specific efforts among labs. It could strive for coordinated sharing of existing infrastructure across Europe by providing timely access for prioritized programs. It could also be used to describe and agree on R&D activities to be executed by the National Labs in support of CERN's mission and considered in-kind contributions or partially or fully funded.

Presently the roadmap takes a very broad look at facility and technology options. After (and if) the European Strategy for Particle Physics (ESPP) makes a prioritization decision, the Accelerator Platform must be reprioritized. Nevertheless, for the long-term future of particle physics R&D, some of the other studies should be maintained at an appropriate level.

The present program ends in 2026. Taking note of our recommendations, we support the continuation of the program, since it can provide great value.

In Table 2 (see appendix) an overview of the present status of the program is provided. The color is describing the general state of the program by pillar with respect to the goal defined in the 2022 plan. The facility pillar High-gradient plasma and laser accelerators is the only one that was substantially rewritten during this time, and we have reviewed the new plan. The criteria in the first column of Table 2 are defined in more detail in Table 3 (see appendix).

The R&D cost question in the table is the only one that goes beyond the present R&D status and the timeline of the platform program (end 2026) to assess the cost request from the leadership of the respective pillar.

References

[1] European Strategy for Particle Physics - Accelerator R&D Roadmap, N. Mounet (ed.), CERN Yellow Reports: Monographs, CERN-2022-001, Geneva, 2022. <https://doi.org/10.23731/CYRM-2022-001>

[2] 2020 update of the European Strategy for Particle Physics. Technical Report CERN-ESU-015, (Brochure), Geneva, 2020. <https://cds.cern.ch/record/2721370>.