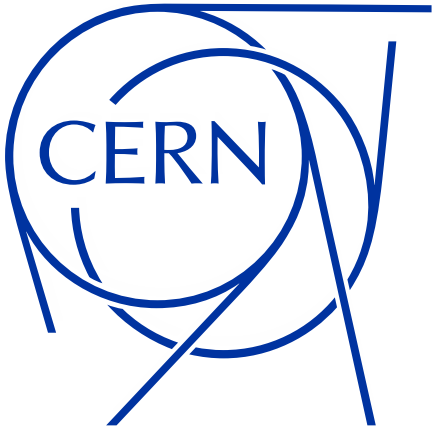


Implementation of the European Strategy

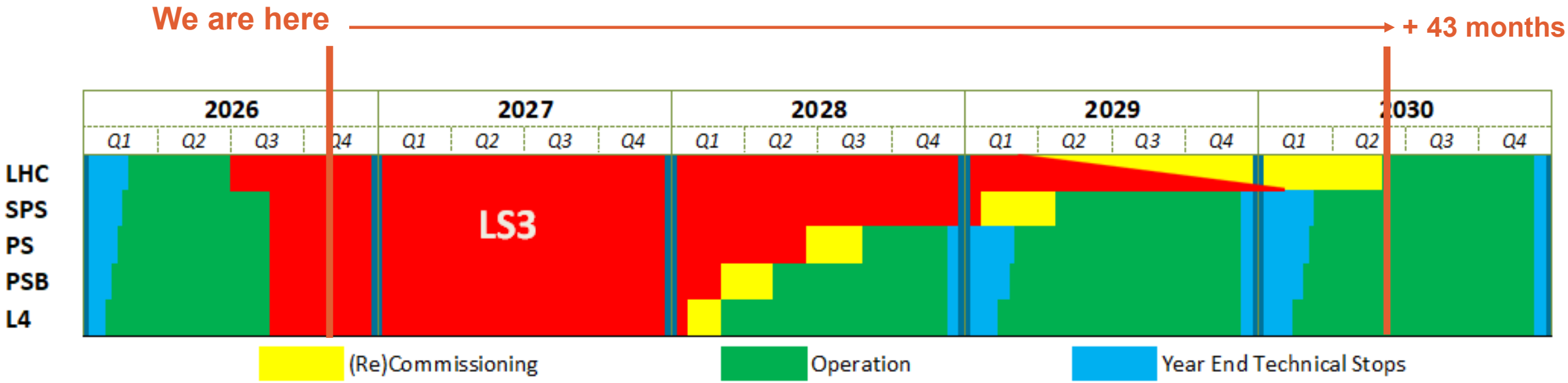
Mark Thomson (CERN)

ICFA Seminar, Toyama, Japan

4 November 2026

Reminder – where are we today?

As of 29 June, the LHC entered Long Shutdown 3



Maintaining this schedule is the highest priority for CERN

- essential to maintain momentum for CERN's next flagship collider: HL-LHC
- Important for the transition to the next long-term project FCC-ee
- **good news**: smooth transition from LHC operations to LS3 and HL-LHC
  - See Oliver Brüning's talk tomorrow
- **good news**: similar positive start to LS3 from ATLAS and CMS

The main topic of today:
“From European Strategy for Particle Physics to implementation”

Clear flow from ESPP to CERN Strategy to MTP

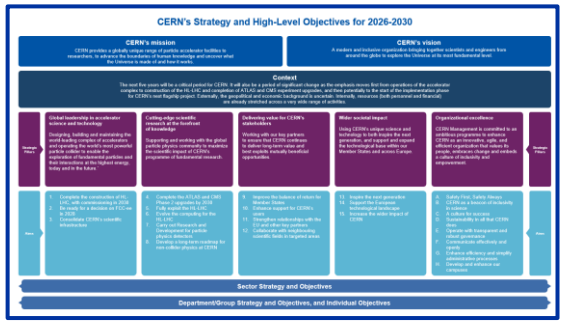
European Strategy was updated by CERN Council in May 2026

- Clear set of scientific priorities for the medium- and long-term
  - Based on extensive consultation and consideration as recorded in the Physics Briefing Book and Deliberations Document



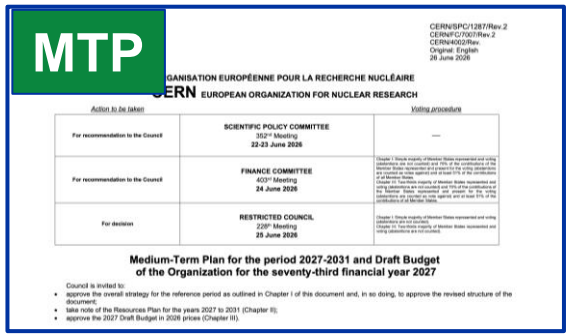
CERN's Strategy 2026-2030 approved by Council in June 2026

- CERN's scientific strategy follows closely the priorities of the European Strategy for Particle Physics
- CERN's strategy is also a strategy for the Organization as a whole



CERN's MTP 2027-2031 approved by Council in June 2026

- CERN's financial plan follows CERN's strategic priorities and underpins the **implementation of the European Strategy**
- **This is a baseline financial plan for the next 5 years**



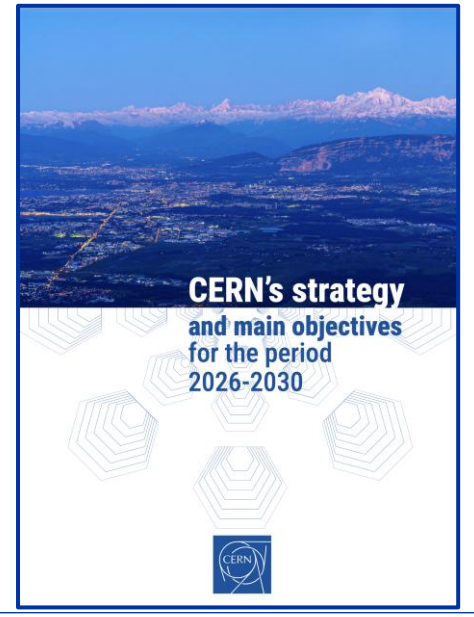
Five pillars of the CERN strategy

The CERN strategy is structured around five strategic pillars

- **Global leadership in accelerator science and technology**
- **Cutting-edge research at the forefront of knowledge**
- Delivering value for CERN's stakeholders
- Wider societal impact
- Organisational excellence

The approved CERN Strategy is now public

- Strong links to the European Strategy for Particle Physics
- Strong focus on **HL-LHC (machine and detectors)** and **FCC-ee**
- We are also developing several areas of strategic importance
  - AI Strategy and Implementation plan
  - Strategy for High-Field and High-Temperature Superconducting Magnet development at CERN
  - Plans for CERN site development, etc…



European Strategy underpins CERN's strategy

Top Priority – full exploitation of the LHC and HL-LHC

- HL-LHC and ATLAS and CMS upgrades are CERN's top priority
- Full exploitation of HL-LHC includes the ALICE and LHCb upgrades during LS4

Highest long-term priority – FCC-ee as CERN's next flagship collider

- Our aim is to be in the position for CERN Council to be able to take a decision on FCC-ee from September 2028 onwards

Non-collider physics at CERN will remain an important part of the programme

- Developing a new roadmap for the future of the non-collider physics programme at CERN by early 2027.
  - Workshop at CERN 2-4 December

Accelerator R&D – focus on top priorities in European Strategy

- Advanced superconducting and normal-conducting Radio Frequency (RF) technology
- Efficient RF power supplies
- Accelerator quality magnets (14-20T), including High-Temperature Super-conductors (HTS)

Key scientific and technical priorities in the European Strategy for Particle Physics

Overview

The next few slides:

- will focus on the key scientific priorities in the European Strategy update and CERN's role in the implementation
  - but cannot cover everything, apologies if I have omitted a favourite topic
- Aim is to give an overall sense of progress, both in terms of priorities from the European Strategy update and ultimately links to budgetary allocations

European Strategy Highlights: Science

LHC and HL-LHC: machine, experiments and physics

- "The full exploitation of the physics potential of the LHC and the HL-LHC and the completion of the high-luminosity upgrade **remain the highest priorities** of European particle physics"
- "Every effort must be made to complete the HL-LHC upgrade within the **current schedule**"

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The Importance of HL-LHC

The construction of the HL-LHC and the ATLAS/CMS upgrades will dominate the next four years at CERN

- Long Shutdown 3 (LS3) for the LHC commenced on 29 June 2026
- The plan and **clear intent** is to be commissioning the machine and detectors in 2030

This is a major task

- The HL-LHC installation will be the largest project undertaken by CERN in around 20 years
- The Phase 2 detector upgrades, are the largest projects undertaken by ATLAS and CMS since the construction of the original detectors

The HL-LHC *and* the detector upgrades represent the highest priority for CERN in the coming years

- Meeting the current schedule, which is our intention requires **laser focus**
- Accordingly, CERN is prioritising resources during LS3 to maximize the likelihood of success

HL-LHC and the Phase 2 upgrades are CERN's highest priorities

HL-LHC machine and detectors

Main priorities (machine)

- **Completion of the HL-LHC with commissioning in 2030**
  - Highest priority for CERN and this is reflected in our financial and personnel planning, e.g.

MTP

Added explicit “Working Allowance” to mitigate technical and schedule risks for **HL-LHC**
Added the additional resources identified by the 2025 HL-LHC cost and schedule review
Additional resources for other highest priority areas

Main priorities (phase 2 upgrades)

- **Completion of the ATLAS and CMS Phase 2 upgrades by 2030**
  - Alongside the HL-LHC, the ATLAS and CMS upgrades are the top priority. Measures include

MTP

Added contingency to mitigate technical and schedule risks
- Earmarked contingency will allow a rapid response to issues

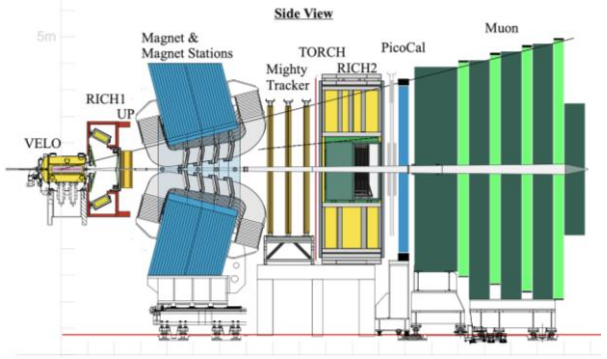
Additional Limited Duration “LS3 posts” to support the upgrades of ATLAS and CMS
Financed cost increases of the critical CO_2 cooling systems for ATLAS and CMS

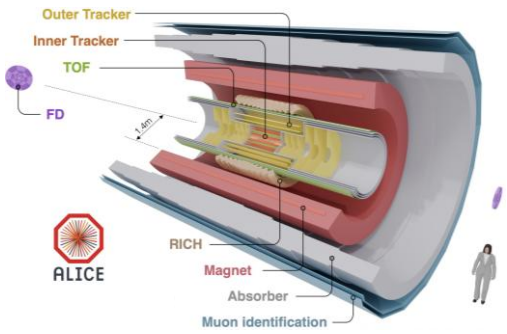
“Fully exploit HL-LHC” includes LHCb and ALICE

Phase 2b upgrades (ALICE and LHCb) are key components to the HL-LHC scientific programme

- In the 2026 MTP added
  - Full LHCb core costs (CERN contribution)
  - Full ALICE core costs (CERN contribution)
  - Placeholder budget for host laboratory support during LS4

MTP





CERN intends to contribute to ALICE and LHCb at the level of the “fair share” of the respective middle Phase-2b upgrade scenarios

At its June meeting, the CERN Research Board approved ALICE and LHCb to produce Technical Design Reports for the Phase 2b upgrades

- Ongoing discussions with Funding Agencies to understand affordable scope of the upgrades

European Strategy Highlights: Science

The next CERN Flagship collider Project: FCC-ee

- “The electron–positron Future Circular Collider (FCC-ee) is recommended as the preferred option for the next flagship collider at CERN”
- “A descoped FCC-ee is the preferred alternative option for the next flagship collider at CERN”

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FCC was a major topic of the update of the ESPP

Some key points:

- European Strategy update identified FCC-ee as the clear preferred option for CERN's next flagship collider.
  - consensus within CERN's Member States and beyond
- A descoped version of FCC-ee was identified as the lower cost alternative option
- In CERN's strategy FCC-ee is identified as the *highest long-term priority*
- We are progressing the design and the supporting documentation to a point where the CERN Council could take a decision from September 2028 onwards
  - further details in M. Benedikt's presentation tomorrow
- **Following the European Strategy Update, at this time, the FCC-ee is the only option being considered for CERN's next flagship collider project**
- CERN Council will be asked for a decision on FCC-ee and not a choice between options

The path is set…

Council resolution on European Strategy invites the CERN management:

- (20) to use the Strategy update as input for its Medium-Term Plan and the ongoing studies towards the FCC-ee as the possible next flagship project at CERN;
- (21) to initiate discussions with the relevant authorities and entities in the Member and Associate Member States, as well as non-Member States and the European Union, with a view to obtaining pledges of additional cash and/or in-kind contributions to the cost of constructing and operating the FCC-ee, and, on this basis, to develop a financially feasible funding plan for the possible FCC-ee project;
- (22) to provide annual reports on the implementation of the Strategy update and the necessary information to support national decision-making processes; and
- (23) to make every effort to ensure that the Council is in a position by 2028 to take a decision on the FCC-ee, taking into account elements such as the scientific, technical and financial feasibility of the project.

This clear mandate from CERN Council was a major step forward

FCC Reference Design Phase Timeline

Planned FCC Phases:

- 2026-2028: Reference Design Phase (RDP, previously referred to as pre-TDR Phase)
- 2029-2033: Technical Design Phase
- 2033- : Project Implementation

Selection of the proposed "Council-level" steps/milestones

- Mar 2026: discussion of Reference Design Phase scope and deliverables
- **Jun 2026: Council approval of the FCC-ee Reference Design Phase**
- Sep 2026: Council approval of Reference Design Phase governance
- Dec 2026: Council discussion on the main features of the funding model
- Mar 2027: Council feedback on FCC-ee governance model
- Dec 2027: Establishment of the FCC-ee review process
- Jul 2028: SPC/FC review of the FCC-ee RDP
- Sep 2028: Council review of FCC-ee RDP



FCC-ee Comments

The next two years will be critical to our success

- **FCC-ee** is the clear best option for the future of CERN **and for global particle physics**
  - **the outcome of the European Strategy Update is crystal clear**
- At CERN, we will do everything possible to ensure the realisation of FCC-ee
- and we have a clear plan of work
  - details of the recent impressive progress in tomorrow's presentation

At this time, it is important that the whole community gets behind the collective goal to secure FCC-ee as the next flagship collider

European Strategy Highlights: Science

Other research directions / Synergies with neighboring fields

- “European contributions to both accelerator-based and non-accelerator neutrino and dark matter experiments are essential and should be supported”
- “CERN should continue to provide support to the global long-baseline neutrino programme via the Neutrino Platform. The collaboration between CERN and non-accelerator-based experiments on technologies of mutual benefit should be continued”
- “The ecosystem of European particle physics laboratories should continue to support a broad, diverse spectrum of key precision experiments in particle physics”
- “CERN should continue its involvement in experimental nuclear physics and astroparticle physics at the current level”

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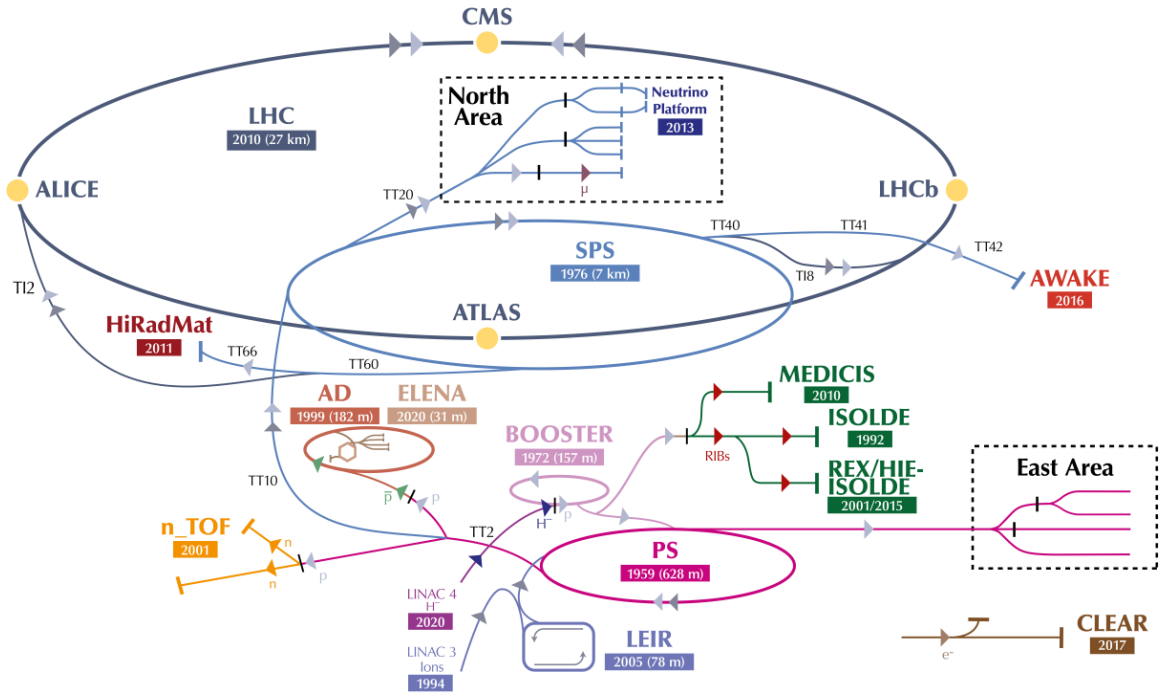
For CERN: the focus is on scientific diversity with CERN’s accelerator complex (development of non-collider physics roadmap) and neutrinos

Other European laboratories will contribute to the wider scientific diversity programme – being mapped out in Laboratory Directors Group

Other research directions at CERN

Main priorities at CERN

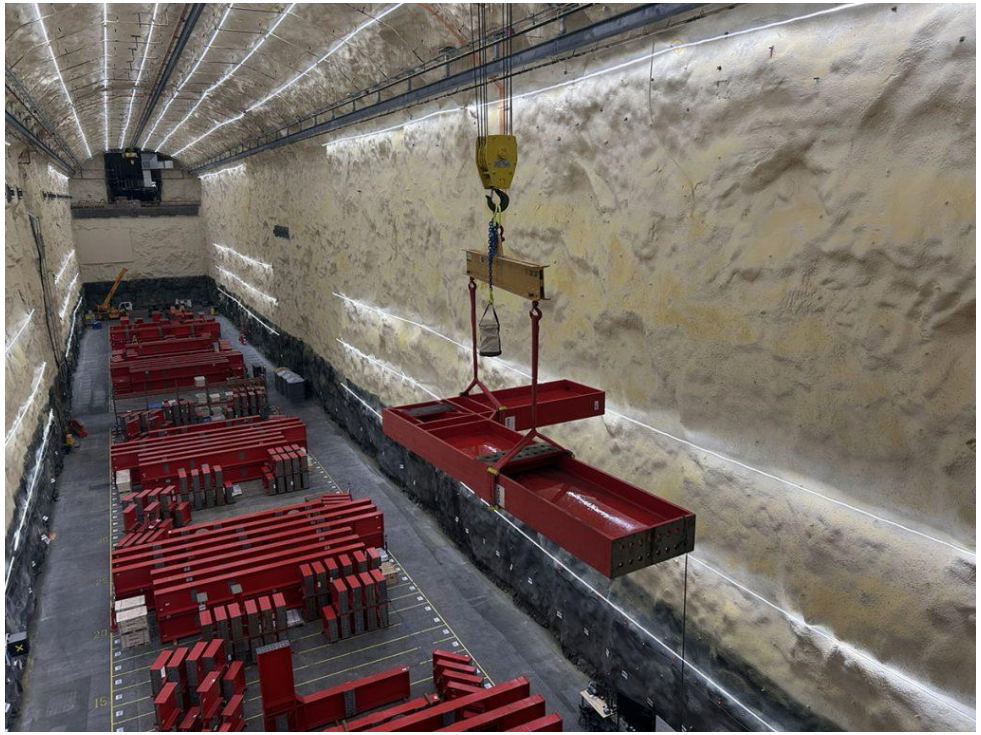
- **Develop a long-term roadmap for non-collider physics at CERN**
  - Evolution of the “Physics Beyond Colliders programme” which has developed many ideas for options for new projects
  - But also covers potential future developments elsewhere: ISOLDE, AD/ELENA, AICE, …
  - This work is progressing well with input from CERN’s scientific committees and a wider community consultation
  - Workshop at December 2-4 at CERN
- **BDF/SHiP remains a priority**
  - But need to make progress on funding model for SHiP



Other research directions at CERN

Neutrinos (long-baseline)

- **As part of the European Strategy, CERN continues to support the long-baseline neutrino programme outside Europe through the neutrino platform**
  - ProtoDUNE detectors at CERN
  - Responsibility for providing the first two DUNE cryostats in South Dakota
    - Installation commenced two days ago !
  - In addition, strengthening contributions to Hyper-Kamiokande



European Strategy Highlights: Science

Theory

- Europe should maintain a strong and diverse particle theory landscape, from formal to phenomenological aspects, while further strengthening and leveraging connections to neighbouring fields.
- Collaborative efforts to improve the precision of theoretical predictions should be recognized and supported. Europe is world-leading in these areas and should strive to remain so by attracting, fostering and retaining early-career global talent. CERN should continue to be an integral part of all these efforts.

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Reflects the importance of theoretical research from formal theory to LHC and FCC-ee phenomenology and precision calculations

- ongoing external review of CERN-TH activities
- opportunities from AI

European Strategy Highlights: Technology

Accelerator science and technology

- In order to realise the visionary plan presented, the **highest priority** must be the development and industrialisation of key technologies: advanced superconducting and normal-conducting RF structures, efficient RF power sources and accelerator-quality magnets in the 14–20 T range, including those based on high-temperature superconductors.
- Demonstration of high-current multi-turn energy recovery in linacs constitutes an important step towards power-efficient lepton accelerators for a broad range of applications and should be pursued.
- The longer-term development of advanced technologies, such as high-gradient wakefield acceleration and those underpinning bright muon beams, should be supported at an appropriate level. Synergies with the US initiative on muon collider R&D should be exploited.

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At CERN the focus will be on the highest priority areas, working in collaboration with our partners

e.g. CERN Strategy on High-Field and HTS Magnets

Built upon the experience and success of collaborative LHC & HL-LHC magnet development

01

High-field superconducting accelerator magnets

Pushing the field frontier

CONDUCTOR FAMILIES

- Nb_3Sn (LTS) 
- REBCO (HTS) 

REBCO – Rare-Earth Barium Copper Oxide

02

Low- to medium-field superconducting magnets

Efficient, scalable systems working at higher temperature

CONDUCTOR FAMILIES

- MgB_2 (MTS) 
- REBCO (HTS)

03

Societal & industrial applications of superconductivity

Translating technology to impact

CONDUCTOR FAMILIES

- NbTi (LTS)
- Nb_3Sn (LTS)
- MgB_2 (MTS)
- REBCO (HTS)

LTS: Low Temperature Superconductor MTS: Medium Temperature Superconductor HTS: High Temperature Superconductor

- Increased emphasis will be placed on HTS developments both at High Fields and Higher Temperatures
- Focus on accelerator dipole and higher order magnets with less effort on high-field solenoids

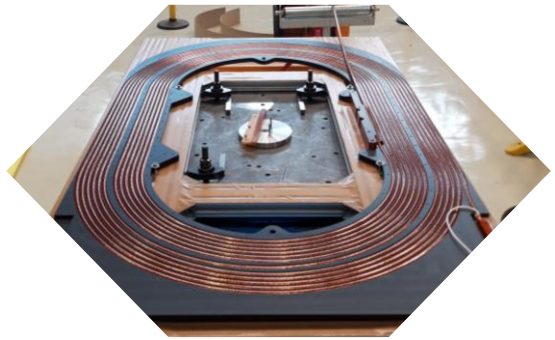
e.g. CERN Strategy on High-Field and HTS Magnets

The High Field Magnet Programme – an International Collaboration

- Main Goals for 2030
  - Prove Low Temperature Superconducting (LTS) technology for 14 T short model dipoles
  - Prove High Temperature Superconducting (HTS) technology for dipole demonstrators at 14 T
- Targets for 2035
  - Prove LTS technology for 5-m-long 14 T dipoles and push HTS technology towards 20 T

Low to Medium Field Applications – focus on higher temperature technology

- Applications where higher-temperature superconducting magnets provide a compelling system-level advantage
- Near-Term demonstrator
  - EESD (Energy-Efficient Superferric MgB_2 Demonstrator) operated at 20 K, paving the way to large, low-field magnets such as the SHiP spectrometer magnet
  - For example: SHiP MgB_2 spectrometer (50 kW superferric v 850 kW resistive)



EESD

European Strategy Highlights: Technology

Artificial Intelligence

- The European particle physics community must further intensify its activities in AI and sustain them with adequate resources.
- A roadmap, coordinated among CERN and national laboratories, institutes and universities, should be developed to prioritise AI activities, taking into account synergies with international partners and other communities.

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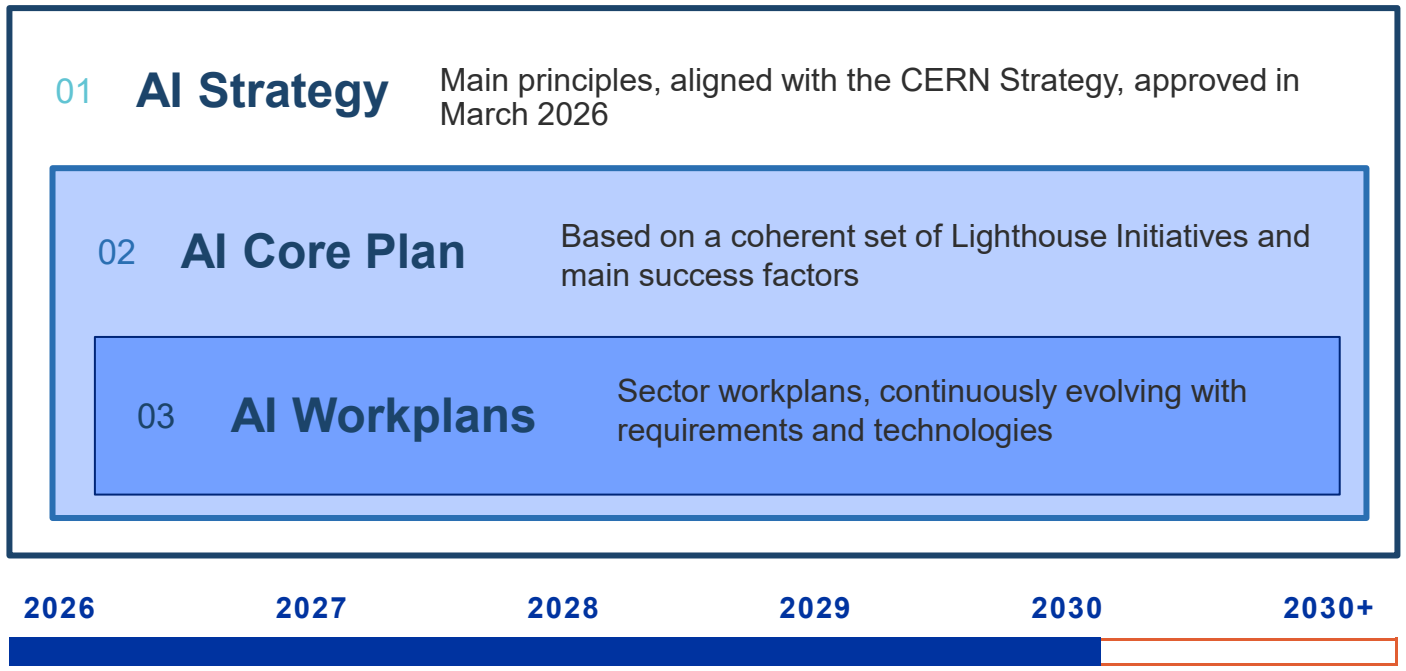
This is work in progress. Needs effective linkage between CERN, national laboratories in Europe and beyond, and the experimental collaborations:

- a coordinated international effort for particle physics?
- involvement of the large LHC experiments is essential

CERN AI Strategy

The implementation plan for CERN's Artificial Intelligence Strategy has been endorsed by CERN management

- The plan translates CERN's AI Strategy 2026–2030 into a phased programme of actions, governance and resources, establishing AI as a core organisational capability
  - Implementation phased through 2030, progressing from foundations and scale-up to production
  - Will need to be a collaborative effort with the community and beyond



Three pillars of the AI Strategy

At the core of the Strategy and the Plan, aligned with the top-level CERN strategic pillars. Every Lighthouse Initiative contributes to one or more.

- **P1** AI for Science
- **P2** AI for Operations
- **P3** AI for Impact

Implementation: CERN AI Lighthouse Initiatives

Infrastructure

Common AI infrastructure, information retrieval, edge AI technologies and processes the whole Laboratory can build on



LH-01
Common AI Infrastructure and Platform

Shared CERN-wide, compute (GPUs), software and AI models platform, designed to satisfy today's known requirement and to enable scaling-out for future needs, starting from support for LLM applications.



LH-02
AskCERN: Information Discovery

Interactive portal for knowledge discovery and retrieval across CERN and community-wide repositories (CDS, EDMS, INSPIRE) and experiments and accelerators technical documentation.



LH-03
Edge AI for Real-Time Data Processing

Built on NextGen Triggers project to extend the common model-to-firmware pipeline for hardware-aware training of AI models for FPGA/ASIC development and deployment.

Applications & Models

Simulation, operations, digital twins and the CERN physics foundation model



LH-04
Universal Fast Simulation Engines

Shared, community-validated AI fast-simulation tools complementing Geant4-based simulation and AI-enhanced event generators for speedup and computing efficiency.



LH-05
AI-Driven Operations and Equipment Support

Agentic AI monitoring equipment degradation, reducing downtime, a first-line assistant beside piquet, operator and shifter, built once and shared across different Groups.



LH-06
AI-Assisted Accelerator Systems Design

Design an accelerator system end to end with AI in the loop: surrogate-based optimisation of geometry, materials and operating parameters



LH-07
Physics Foundation Model

A large-scale physics-aware foundation model to reconstruct and simulate LHC collisions, tuneable to specific tasks.

Horizon 2030+

More speculative, partnership-dependent, mostly beyond the 2030 plan



LH-08
CERN AI Agents for Particle Physics

Agentic AI customised on non-public CERN data to assist physicists with data analysis and interpretation.



LH-09
AI-Assisted Detector Design

End-to-end differentiable optimisation of detector geometry, materials and technology jointly with the reconstruction chain, balancing physics performance against cost.



LH-10
AI-Driven Material Discovery for Future Colliders

AI-driven discovery of materials for future accelerator magnets and detectors.

Concluding Remarks

Concluding remarks

Our mission and our collective challenge

- **The coming years will be a critical period for particle physics at CERN**
  - The **HL-LHC** machine and detector construction are moving at pace, **both of which are at the scale not seen at CERN for the last 20 years**
  - In parallel, we are aiming to progress **FCC-ee**, as CERN's next flagship project after HL-LHC, **which would be the largest collider project ever undertaken**
  - At CERN, we are focusing resources on the top priorities for the future of CERN and the future of collider-based high-energy physics: **HL-LHC** and **FCC-ee**

FCC-ee is a remarkable scientific opportunity

- **Potentially a once-in-a-generation opportunity to secure a bold vision for the future of particle physics**
- **It is important that the whole community gets behind this vision**

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Thank you



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