CERN/SPC/1153/RA
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CERN's main objectives for 2021-2025

Fabiola Gianotti, on behalf of CERN's Directorate
Council, 25/3/2021

Introduction

The period 2021-2025 will be crucial for the full exploitation of LHC and to lay the foundations for a compelling, exciting scientific future for CERN.

At the same time, the world is facing unprecedented challenges → CERN should multiply its efforts to increase its "return" to society.

3 main objectives:

- ❑ Deliver world-class scientific results and knowledge
- ❑ Increase the return to the Member and Associate Member States
- ❑ Strengthen CERN's impact on society

Note: projects and activities described here are or will be carried out in strong cooperation with other Labs and institutes in the Member and Associate Member States and beyond.

Deliver world-class scientific results and knowledge

CERN's vision and objectives are based on the 2020 update of the European Strategy for Particle Physics (ESPP)

Current programme: main objectives

Successful Run 3

Full exploitation of LHC physics potential: ALICE, ATLAS, CMS, LHCb and smaller experiments
Challenge: ramp-up of significantly upgraded injectors to target performance → see M. Lamont's talk

Completion of HL-LHC and Phase-2 upgrade of ATLAS and CMS for installation in LS3

(Current) challenges:

- ❑ Nb_3Sn magnets
- ❑ ATLAS: inner tracker; CMS: end-cap calorimeter; both: microelectronic chips

Scientific diversity programme

HIE/ISOLDE, n_TOF, AD/ELENA, fixed-target experiments, etc.
Physics exploitation of upgraded injectors.

Neutrino Platform

Essential role to support European community engaged in long baseline projects in US and Japan; important scientific and technological contributions to DUNE/LBNF and T2K.
Single-phase "module zero" and validation of "vertical drift" technology are crucial goals in coming years.
Challenge: construction of two cryostats for DUNE (new technology; cost control; etc.)
→ new NP organisation in place; review committees established → see J. Mnich's talk

Theory

Essential to open new avenues of exploration and motivate experimental investigation.
Will continue to support broad range of studies related to Lab's experimental programme and beyond
Challenge: increase diversity of workforce in TH department.

Additional remarks

Success of current scientific programme is essential milestone for long-term future
as it will demonstrate the strength of CERN and its community and ability to meet the highest expectations → pre-requisite for future, more ambitious projects

CERN's support to the experiments is crucial for successful Phase-2 upgrades and full exploitation of HL-LHC

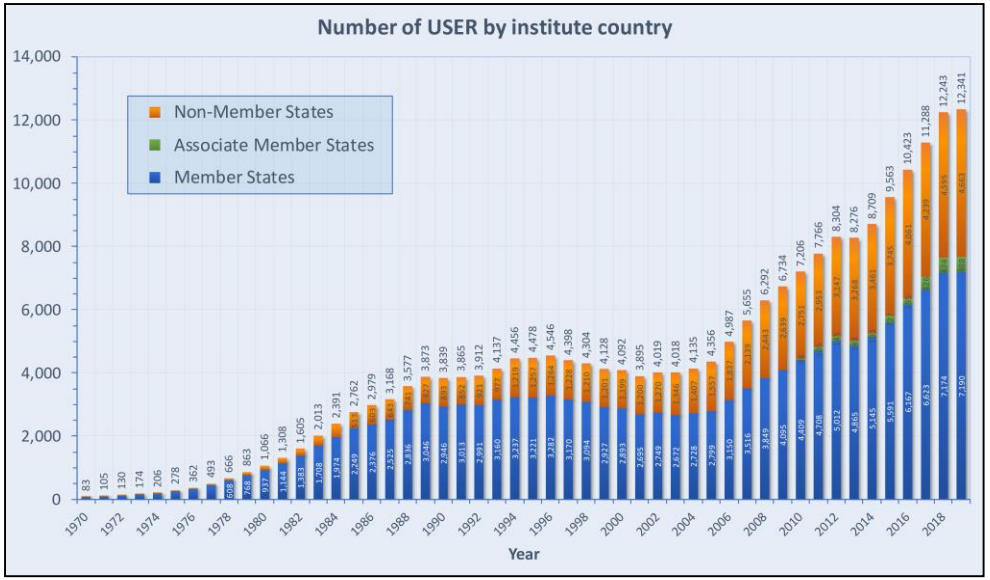
Ongoing/future initiatives include:

- ❑ host lab responsibility → covered in 2020 MTP until end of LS3
- ❑ workforce → new "Graduate Programme" being developed; new Experiment Associate status; etc.
- ❑ support to state-of-the-art microelectronic devices (a common issue for all experiments)
- ❑ management of experiments' financial accounts → support being set up with help of FAP Dept
- ❑ project status reviews through various committees
  (currently: LHCC, Upgrade Cost Group, P2UG, Scrutiny and Computing Scrutiny Groups)

CERN is primarily a user facility

Ongoing/future initiatives to strenghten support for users include:

- ❑ significant additional resources in 2020 MTP to renovate buildings and site (e.g. new B140)
- ❑ WG set up to review and improve existing services for users → see J.Mnich's talk



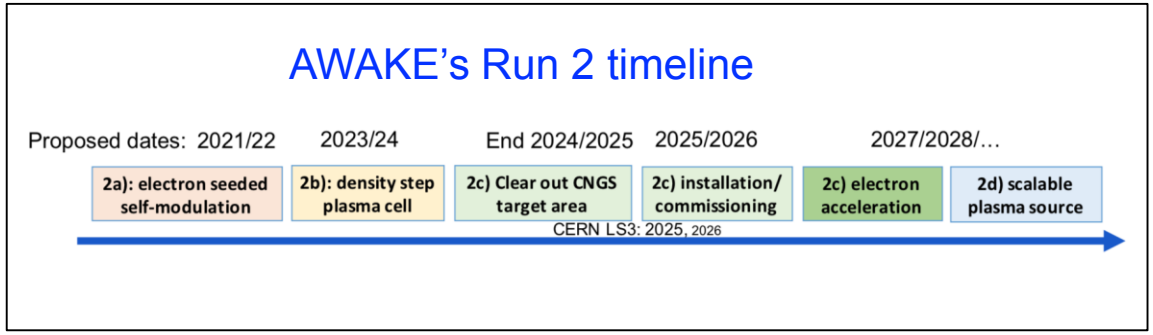
Preparation of CERN's future: main objectives

Accelerator R&D

Main goal: develop technologies needed for the future of the field, including:

- ❑ High-field superconducting magnets
- ❑ High-gradient (warm) accelerating structure and other linear collider key technologies
- ❑ Muon collider technologies: new initiative started in 2020
- ❑ Plasma wakefield: AWAKE (proton-driven)
- ❑ R&D on variety of technologies motivated by new ideas and operational needs from current facilities.

Resources for all of above activities allocated in 2020 MTP and will be adapted in future as needed.
This programme will be reviewed once LDG's Accelerator R&D roadmap completed.



Run 2 goal:
demonstrate ~ GV/m gradient and beam quality/emittance
26 MCHF allocated in 2020 MTP.
Cost and Schedule Review in 2021

Preparation of CERN's future: main objectives

Options for a future collider

FCC

Assess technical and financial feasibility: tunnel, technologies, external funding, support in community and beyond (communication!)

Goal for next ESPP: "Feasibilty Study Report" (to be completed by end 2025)

CLIC

X-band acceleration technology towards readiness; improve power efficiency; optimise luminosity.

Goal for next ESPP: "Project Readiness Report"

Muon colliders

Work on main challenges: muon source and cooling, fast-ramping magnets and power converters, neutrino background and civil engineering, etc.

Goal for next ESPP: assess if demonstrator (~ 500 MCHF!) and Conceptual Design Report are justified from scientific viewpoint.

Preparation of CERN's future: main objectives

Scientific diversity programme

- Essential to address open questions from perspective complementary to high-energy colliders: e.g. rare processes, searches for feebly interacting particles, etc.
  → Physics Beyond Colliders has become long-term activity; budget tripled in 2020 MTP.
- Some projects may be implemented at European national labs with CERN's support.
- PBC contributes to strengthening collaboration with nuclear and astroparticle physics. It will also explore opportunities offered by new technologies (e.g. quantum sensors)

Computing R&D

Pursue computing technologies to meet requirements of HL-LHC and future projects.
Ongoing initiatives with CERN's participation: CERN openlab, HEP Software Foundation, European Open Science Cloud, CERN's Quantum Technology Initiative, etc.
Opportunities for collaboration with other disciplines (e.g. astroparticle physics, medical applications) and industry.

Detector R&D

Strategic programme on "R&D for future detectors" launched by EP department in 2019:

- develop most promising technologies for detectors at future collider and non-collider experiments;
- particular attention to environmentally friendly solutions;
- emphasis on areas where CERN has significant expertise and infrastructure.

Programme will be reviewed once ECFA's Detector R&D roadmap completed.

Collaborations with neighbouring fields

Collaboration in areas of common interest will be strengthened, as well as sharing of CERN's technologies and competencies, within available resources

→ allow Member and Associate Member States' investments in CERN to also benefit other challenging projects to which they contribute.

Nuclear Physics

- Ongoing programme: HIE/ISOLDE, n_TOF, NA61, heavy ions at LHC.
  Recent significant upgrades, more to come (e.g. ALICE)
  Heavy-ion programme is important component of full exploitation of LHC/HL-LHC.
- Strong collaboration with facilities in Europe and beyond (e.g. FAIR, ESS, potentially EIC in US)

Astroparticle Physics

Growing opportunities, as more and more similar challenges (project scale and complexity, technologies, ...)
Ongoing support and collaborations include:

- Recognised Experiments (75% from astroparticle);
- development of computing and other technologies of common interest;
- consultancy and assistance in areas where CERN has expertise, such as vacuum, cryogenics (e.g. DarkSide20k cryostat), superconducting magnets, RF, geological studies for underground installations, governance of large projects;
- test-beam availability and support at CERN;
- new centre for astroparticle theory (EuCAPT), initially hosted at CERN.

Increase the return to the Member and Associate Member States

Main objectives

Industrial return

Ongoing/future initiatives to improve include:

- Industrial exhibitions and visits
- Implement recommendations of recently established WG: avoid over-specified requirements; proactively identify items for limited tendering; solid justification and hierarchy's approval required for single-source contracts above 10 kCHF, etc.
- Revise policy for bank guarantees
- Continue to alert departments about geographical spread of their contracts
- Strengthen dialogue with Industrial Liaison Officers on country-specific issues

Supplies, 2017-2020

	Industrial return coefficient (IR)	Number of countries
Well balanced	IR ≥ 1	10
Poorly balanced	0.4 ≤ IR < 1	17
Very poorly balanced	IR < 0.4	4

Main objectives

Human Resources return

Ongoing/future initiatives to improve include:

- Career fairs in Member and Associate Member States
- New Graduate Programme being developed to train future generation of physicists, engineers and technicians → majority will return and bring competencies and experience to their home countries, and a small number may subsequently be hired by CERN.
  New programme will streamline current opportunities, enhance geographical spread of applications → hence the diversity of future talent pipeline. Aim at implementation by end of year.
- New "25 by '25" initiative: enhance nationality diversity in departments and groups with "nationality clusters" above 25% by establishing tailor-made plan for future hires.
  Initiative also aims at 25% employed women at CERN by 2025.

Number of countries vs return for staff and technical students

HR return coefficient (IHR)	Staff	Technical students
IHR > 0.8	17	18
0.5 < IHR ≤ 0.8	3	2
IHR ≤ 0.5	11	11

Main objectives

Technological collaborations

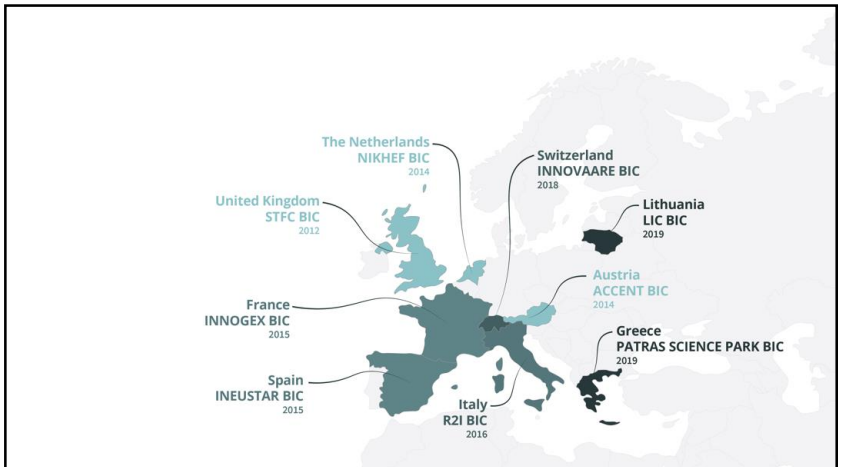
CERN has large number of collaborations with Member and Associate Member States:

- ❑ contributions to projects at other labs/facilities (e.g. GSI/FAIR, ESS)
- ❑ common R&D programmes (e.g. on superconducting magnets; HL-LHC components)
- ❑ CERN infrastructure, expertise and competencies provided for activities at home

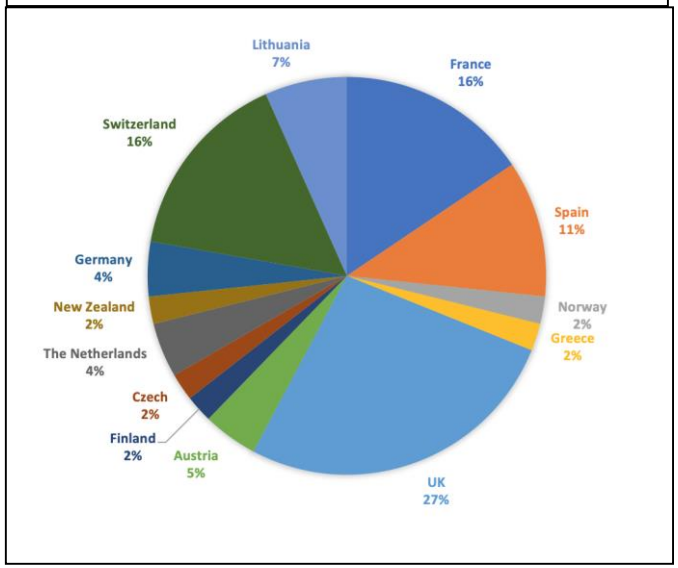
New opportunities in the future: Accelerator R&D and Detector R&D roadmaps; quantum technologies; collaborations with astroparticle projects; etc.

Partnership with industry

Support network of Business Incubation Centres and promote start-ups on CERN technologies (currently 45). Increase opportunities of knowledge exchanges with industry (see G. Anelli's presentation at yesterday's FC); essential role of KT Forum to create links in Member and Associate Member States.



Distribution by country of 45 start-ups



Main objectives

Scientific education

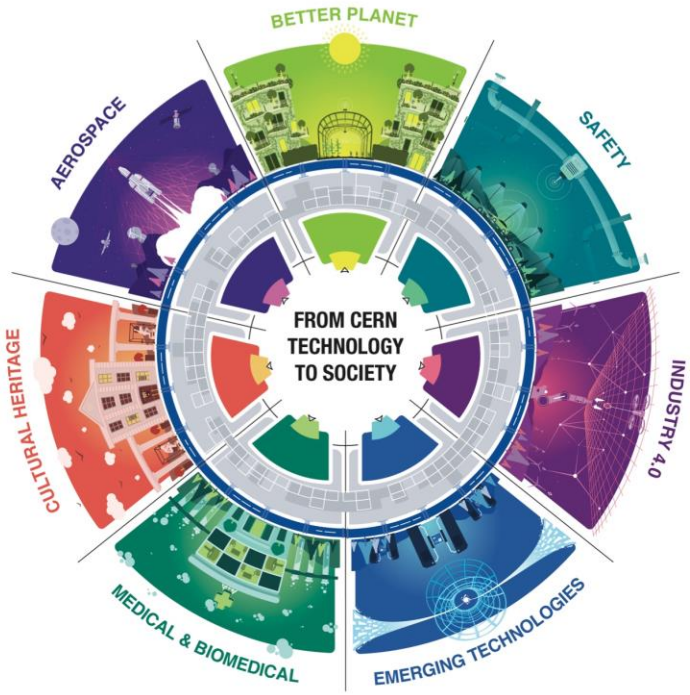
Currently: guided tours on site (150 000 visitors/year); 2 permanent exhibitions (100 000 visitors per year); hands-on experiments at S'Cool Lab (7000 participants per year); teacher's programmes (1000 participants per year); Summer Student programme (300 participants per year); traveling exhibitions; joint public events in Member and Associate Member States

In the future:

- Expand online opportunities developed during Covid (virtual visits, online particle physics course for high-school students, etc.)
- Science Gateway: it will boost the network of scientific outreach and education initiatives in the Member and Associate Member States and provide new opportunities through sharing of material, live link-ups with national events, temporary exhibitions highlighting activities in the Member and Associate Member States

Strengthen CERN's impact on society

Necessary to increase CERN's visibility and the support of governments and the public



CERN impacts on society in many ways

- scientific knowledge: our primary mission
  → need to strengthen communication: share excitement with, and importance for, humanity.
  CERN ECO works with EPPCN on communication and engagement strategy in support of ESPP

- values: collaboration across borders, inclusiveness, openness → relevant as ever!
  "CERN model" taken as an example by other institutions; open science (knowledge, technology and education accessible to all) is crucial to reduce inequities and for sustainable society
  → need to strenghten communication (e.g. CERN's 70th anniversary in 2024, Science Gateway, etc.)

- scientific training: contribution to tomorrow's workforce (society lacks STEM graduates)
  ~ 1600 young people trained annually at CERN (fellows, doctoral and technical students, etc.)
  ~ 3000 PhD students from all over the world
  Several initiaves by experiments, ECFA, CERN to support careers of young people
  New initiatives at CERN: new Graduate Programme; actions to support career transition

- development of advanced technologies: broad range, many potential applications
  → decided to focus primarily on: environment and sustainability; health; computing

Note: CERN's values, competencies and technologies also contribute to the UN SDG, in particular:
3, 4, 9, 16, 17

Sustainability and environment

Minimise Laboratory's impact on environment

- ❑ Implement recommendations of CEPS (CERN Environmental Protection Steering) board for 11 high-priority environmental domains → 25 MCHF allocated over 2019-2023. Include R&D on new, environmentally friendly gases for particle physics detectors.
- ❑ First public environment report released in 2020: current status and ambitious goals for future. Next one Sept 2021, then every two years.
- ❑ Staff member in charge of "green procurement" recently appointed → include environmental considerations in CERN's purchasing processes.

→ CERN aims to establish itself as model for transparent and environmentally responsible research organisation.

Energy saving and reuse

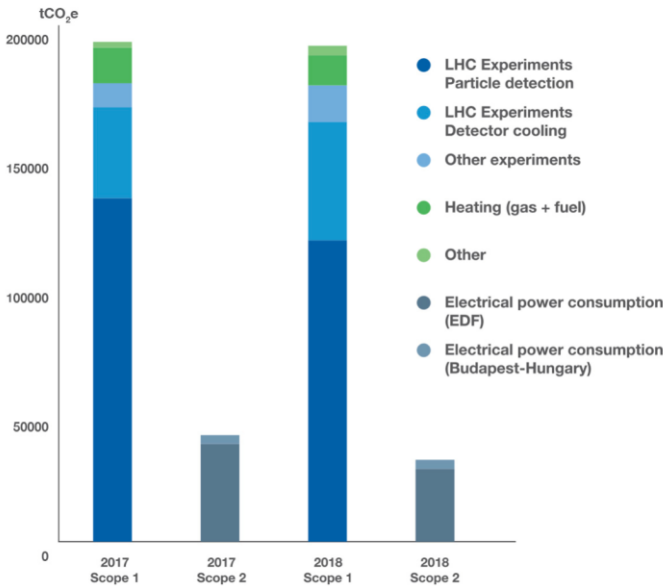
- ❑ Dedicated Energy Management Panel (EMP) → see presentation by S. Claudet Sept 2020
- ❑ East Area renovation in LS2 (pulsed magnets) → from 11 GWh/year to 0.6 GWh/year. North Area renovation in LS3.
- ❑ Heat recovery at LHC IP8 to warm up new housing development in Ferney-Voltaire as of 2022
- ❑ New Computing Centre to provide heating for buildings in Prévessin as of 2024.
- ❑ R&D on efficient power production for future projects (high-efficiency klystrons, etc.) with potential applications in industry

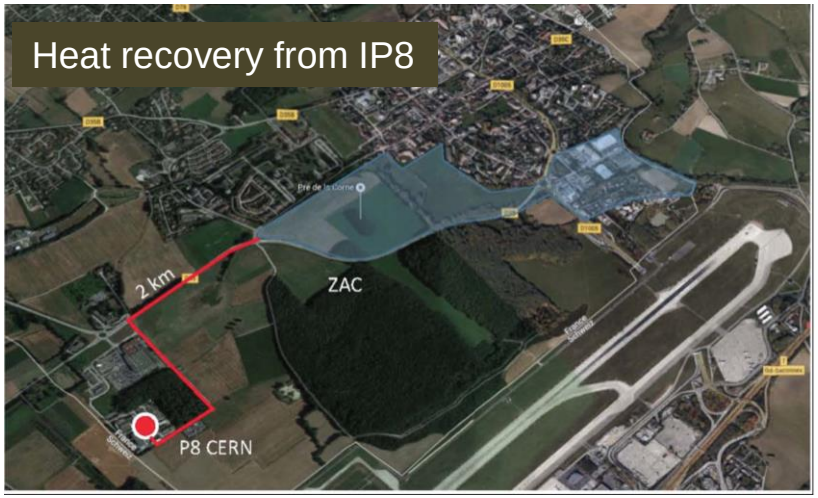
Develop technologies for the environment

- ❑ Vacuum, high-temperature superconducting links for electricity transport, high-efficiency klystrons, etc.
- ❑ Collaboration between Accelerators and Technology sector, HSE unit, KT group

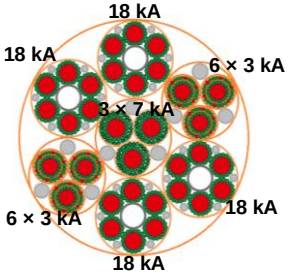
Sustainability and environment

From 2020 Environment Report
Target: reduce emissions by 28% by 2024

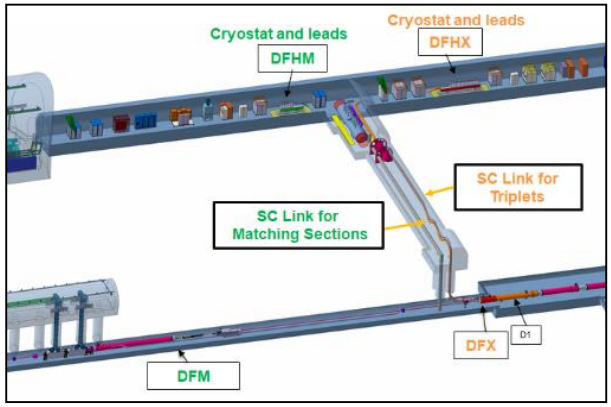




High-current transmission lines for HL-LHC



MgB_2 cable:
$\Phi \sim 90$ mm
$I_{tot} > 100$ kA @ 25 K



Health and computing

Health

Historically one of best examples of spin-off from the field (cancer therapy, imaging, etc.)
New initiatives include:

- R&D on technologies for innovative ion therapy (NIMMS, Next Ion Medical Machine Study): magnets, ion linacs, improved synchrotron designs, superconducting gantries, etc.;
- radiotherapy facility for irradiation with ultrafast bursts of electrons (FLASH) based on CLIC technology: partnership with University Hospital in Lausanne;
- exploitation of MEDICIS facility for non-conventional radio-isotopes;
- detectors and electronics for imaging and dosimetry;
- computing technologies for data storage, management and analysis.

In strong collaboration with hospitals, research centres and industry in Member States and beyond

3D colour X-ray image with Medipix

Computing

Technology mostly driven by industry but CERN (and HEP) have stringent requirements: big data, complexity of problems and algorithms, etc. → appealing to industry (e.g. 20 years of CERN openlab!).
CERN will continue and expand R&D activities in area where it can bring unique expertise: quantum technology, AI, open-access data repository.

Conclusions

The vision and objectives presented here aim at preserving and expanding CERN's multi-faceted role (in science, technology, training and education, collaboration across borders, etc.) and making it more visible to, and recognised by, society, thus ensuring a bright future for the Organization.

Council's feedback is welcome!

EXTRAs

25 by '25

As an International Organisation, we need to reflect the diverse communities of our Member and Associate Member States

The context:

"The particle physics community commits to placing the principles of ***equality, diversity & inclusion*** *at the heart of all the physics community's activities."*

- ESPP 2020 update

The business case:

Companies with more diverse management teams have **19% higher revenues** due to innovation.

- BCG 2018

GENDER target

Goal: 25% women MPEs by 2025

21% now → **25% in 2025**

With a particular focus on women in STEM

NATIONALITY indicator

Goal: more balanced MS return by 2025

25 % indicator

Identify nationality clusters above 25%

With a particular focus on under-represented MS

Sample implementation actions

- Include diversity-positive actions in MERIT & promotion exercises
- Retain the diversity ratio from the longlist to the shortlist
- Mandatory learning: harassment prevention
- Expand spouse / family integration measures
- "Aide Memoire" - tips for inclusive hiring
- Re-launch "blind recruitment" pilot
- Embed inclusive language in VNs and job titles

New Graduate Programme

Training:
More opportunities to employ young graduates to learn on the job, gain experience and expand their network

Diversity/MS return:
Steer & nourish talent pipelines towards more balanced personnel returns

3 schemes:
Fewer, clearer schemes with well-defined identities

Early Career Professionals

WHAT: Real work opportunity for developing skills on-the-job

WHO: Very recent graduates from technician to Master level

Research/Project Grads

WHAT: Time-limited, result-focused research or project-based opportunities for further honing existing skills

WHO: Experienced graduates with Masters or PhD

Fellows

WHAT: Post-doctoral positions in experimental or theoretical particle physicists

WHO: Top ranked category 1 particle physicists with PhD

All would be employed members of personnel (MPE)

CERN contributes to the sustainable development goals

SDG 3 - HEALTH

CERN helps to develop technologies that contribute to better healthcare for all, such as medical imaging and hadron therapy.

THERAPY
Accelerators provide particle beams for more targeted cancer treatment.

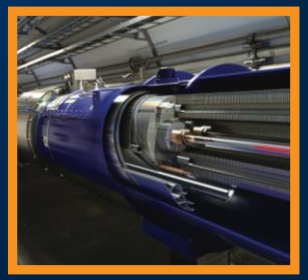
SDG 4 - EDUCATION

Education is one of CERN's core missions. We offer high quality programmes that inspire thousands of students, teachers and young researchers each year.

BEAMLINE FOR SCHOOLS COMPETITION
Students from the two winning teams spend a week at CERN to carry out their experiment using a CERN accelerator.

SDG 9 - INNOVATION

CERN inventions are brought to industry through knowledge transfer, to have a positive impact on society and innovation.



A MAGNET IN THE LHC TUNNEL
Exploring the universe requires new technologies and ingenious engineering to build the machines that explore physics at a new frontier.

SDG 16 & 17 - INTERNATIONAL COOPERATION

CERN is a successful model for international collaboration. CERN gathers researchers from all over the world, contributing to human knowledge and peace, for the benefit of all.

SESAME
This new synchrotron light source in Jordan started operation in 2017. It is a unique collaboration between eight Middle East members, modelled on CERN's governance structure.