

Grundlagenforschung in einer internationalen Perspektive

CERN

The Organization, current research, and education.

Niklas Herff

Was ist CERN eigentlich?



Was hieß « CERN » ursprünglich?

Conseil
Européen pour la
Recherche
Nucléaire

1952



Science for peace

CERN was founded in 1954 by 12 European Member States



23 Member States

Austria – Belgium – Bulgaria – Czech Republic
Denmark – Finland – France – Germany – Greece
Hungary – Israel – Italy – Netherlands – Norway
Poland – Portugal – Romania – Serbia – Slovakia
Spain – Sweden – Switzerland – United Kingdom

3 Associates Member States in the pre-stage to membership

Cyprus – Estonia – Slovenia

7 Associate Member States

Croatia – India – Latvia – Lithuania – Pakistan – Türkiye – Ukraine

6 Observers

Japan – Russia – USA
European Union – JINR – UNESCO

More than 50 Cooperation Agreements with non-Member States and Territories

Albania – Algeria – Argentina – Armenia – Australia – Azerbaijan – Bangladesh – Belarus – Bolivia
Bosnia and Herzegovina – Brazil – Canada – Chile – Colombia – Costa Rica – Ecuador – Egypt – Georgia – Iceland
Iran – Jordan – Kazakhstan – Latvia – Lebanon – Malta – Mexico – Mongolia – Montenegro – Morocco – Nepal
New Zealand – North Macedonia – Palestine – Paraguay – People's Republic of China – Peru – Philippines – Qatar
Republic of Korea – Saudi Arabia – Sri Lanka – South Africa – Thailand – Tunisia – United Arab Emirates – Vietnam

CERN's annual budget
is 1228 MCHF (equivalent
to a medium-sized European
university)

As of 31 December 2021
Employees:
2676 staff, **783** fellows

Associates:
11 175 users, **1699** others

A laboratory for people around the world

Distribution of all CERN Users by the country of their home institutes as of 31 December 2021



Geographical & cultural diversity
Users of **115 nationalities**
and from **77 countries**
~ **23% women**



Member States **6642**

Austria 74 – Belgium 122 – Bulgaria 39 – Czech Republic 227
Denmark 42 – Finland 71 – France 811 – Germany 1129
Greece 133 – Hungary 69 – Israel 67 – Italy 1423
Netherlands 157 – Norway 69 – Poland 278 – Portugal 89
Romania 105 – Serbia 36 – Slovakia 66 – Spain 328
Sweden 88 – Switzerland 372 – United Kingdom 847

Associate Member States **55** in the pre-stage to membership

Cyprus 10 – Estonia 24 – Slovenia 21

Associate Member States **367**

Croatia 36 – India 130 – Latvia 11 – Lithuania 11 – Pakistan 30
Türkiye 122 – Ukraine 26

Observer States **2917**

Japan 189 – Russia 971 – United States of America 1757

Other countries **1194**

Algeria 3 – Argentina 16 – Armenia 10 – Australia 20 – Azerbaijan 3 – Bahrain 2 – Belarus 24 – Brazil 106
Canada 189 – Chile 23 – Colombia 18 – Cuba 3 – Ecuador 6 – Egypt 16 – Georgia 36
Hong Kong 17 – Iceland 3 – Indonesia 6 – Iran 11 – Ireland 6 – Jordan 5 – Kuwait 5 – Lebanon 15
Madagascar 1 – Malaysia 4 – Malta 2 – Mexico 48 – Montenegro 5 – Morocco 18 – New Zealand 8 – Oman 1
People's Republic of China 314 – Peru 2 – Philippines 1 – Republic of Korea 113 – Singapore 3
South Africa 52 – Sri Lanka 10 – Taiwan 45 – Thailand 18 – United Arab Emirates 6

CERN Council

President: E. Rabinovici
Secretary: CERN DG



- (Associate) Member States: jeweils 2 Delegierte
- ex-officio
 - FC Vorsitz
 - SPC Vorsitz
- Verschiedene Beobachter auf Einladung, incl. ECFA Vorsitz

Finance Committee

Chairperson: L. Salzarulo



- (Associate) Member States: jeweils 1-3 Delegierte
- ex-officio
 - Council Präsident(in)
 - SPC Vorsitz

Scientific Policy Committee

Chairperson: H. Montgomery



- 14 individuelle Mitglieder
- ex-officio
 - ECFA Vorsitz
 - Vorsitzende von CERN Komitees (LHCC, MAC, SPSC, INTC)
- ständig Eingeladene
 - CERN DG, Council Präsident(in), FC Vorsitz

Audit Committee

Chairperson: J. Schieck



Tripartite Employment Forum

Chairperson: B. Åsman



Pension Fund Governing Board

Chairperson: O. Malmberg





Council Secretariat
Legal Service

Director General
Fabiola Gianotti 

Internal Audit
Health, Safety, and Environment Unit

Finance and Human
Resources
Rafael Bello 


Research and Computing
Joachim Mnich 

Accelerators and
Technology
Mike Lamont 

International Relations
Charlotte Warakaulle 


Finance and
Administrative Procedures
Florian Sonnemann 

Experimental Physics
Manfred Krammer 

Beams
Rhodri Jones 

Education, Communication,
and Outreach

Human Resources
James Purvis 


Theoretical Physics
Gian Giudice 

Engineering
Katy Foraz 


Diplomatic and Stakeholder
Relations

Industry, Procurement, and
Technology Transfer
Christopher Hartley 

Information Technologies
Enrica Porcari 

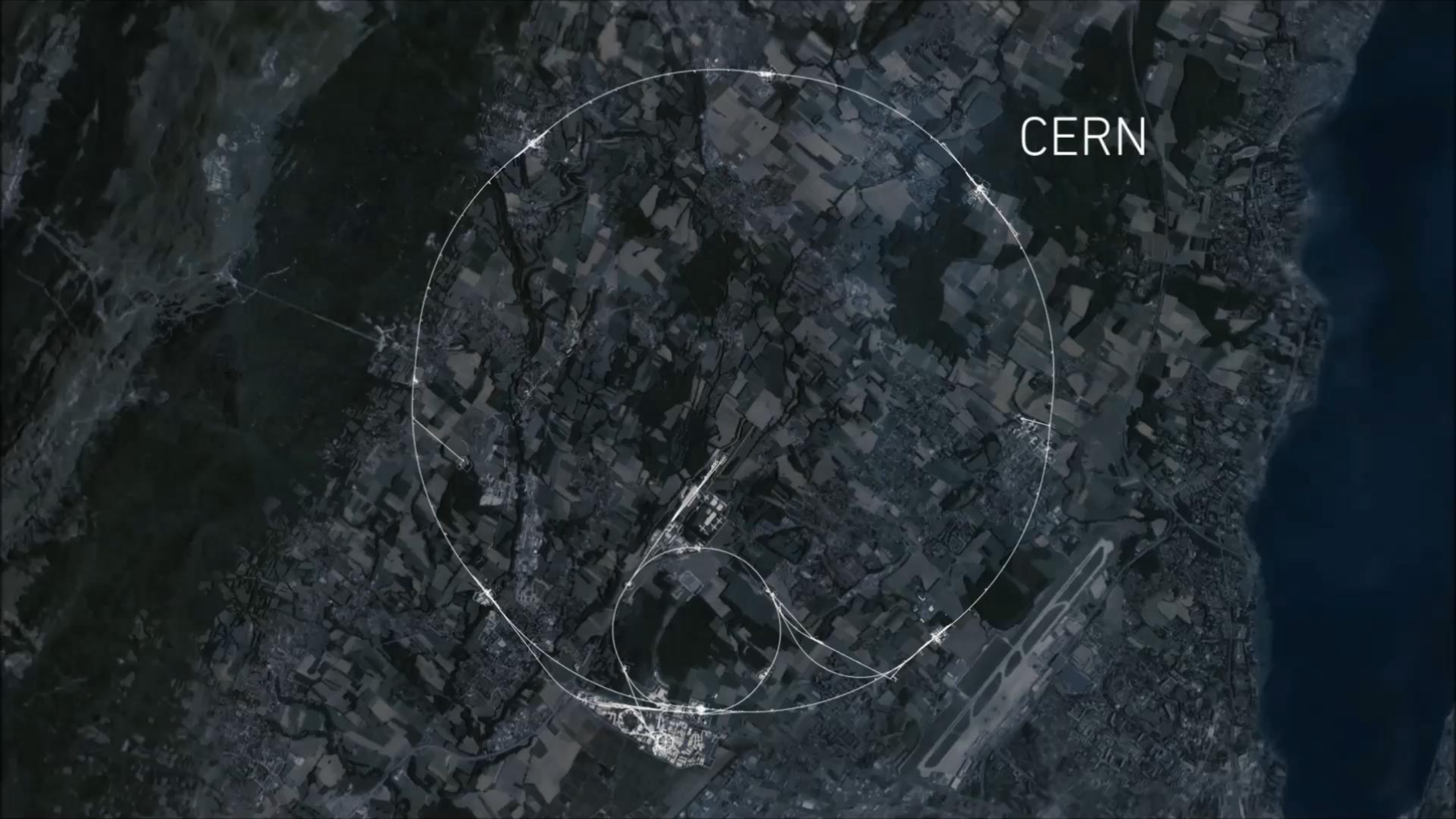
Systems
Brennan Goddard 

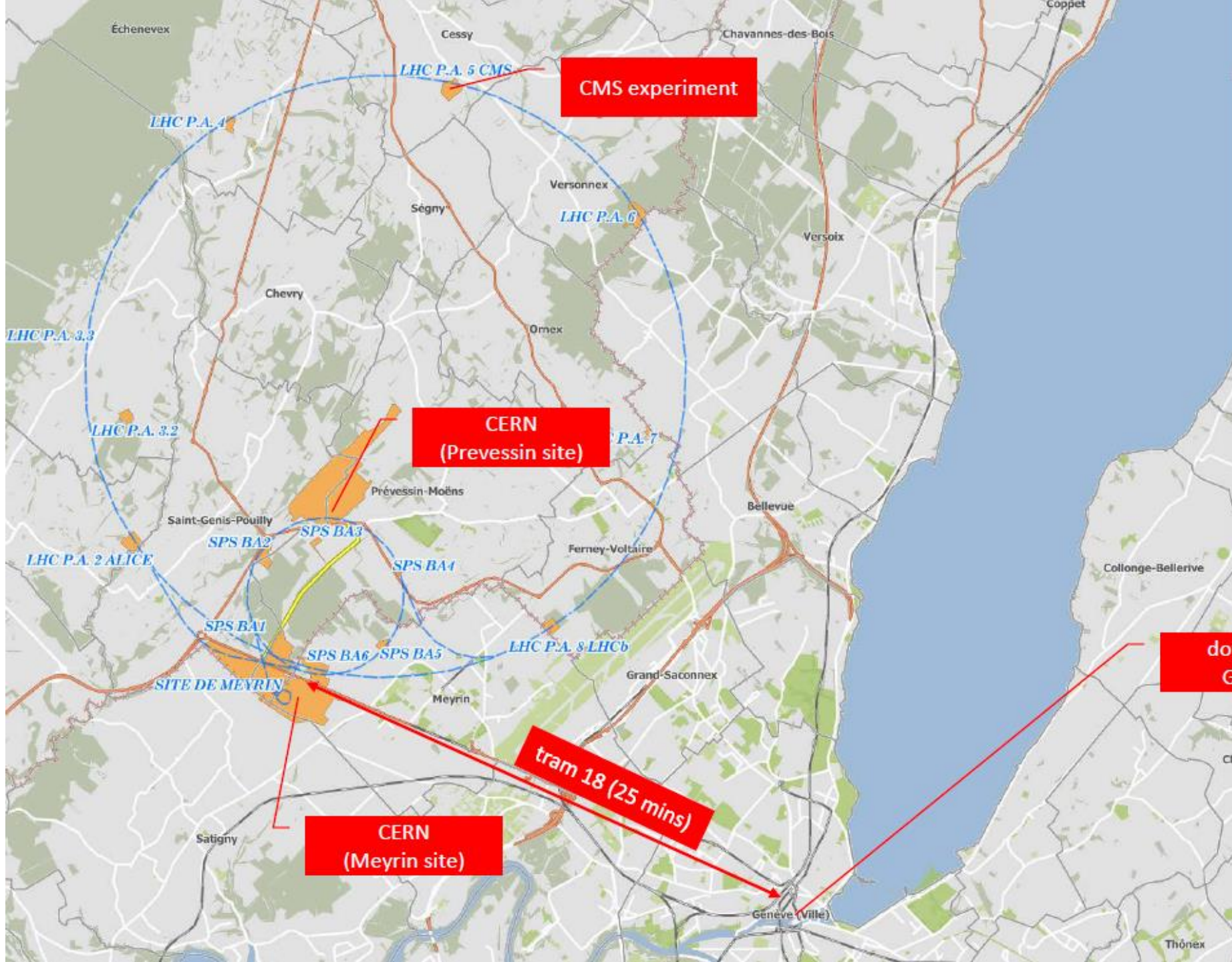
Site and Civil Engineering
Mar Capeans 

Technology
Jose Miguel Jimenez 



CERN





CMS experiment

CERN
(Preveessin site)

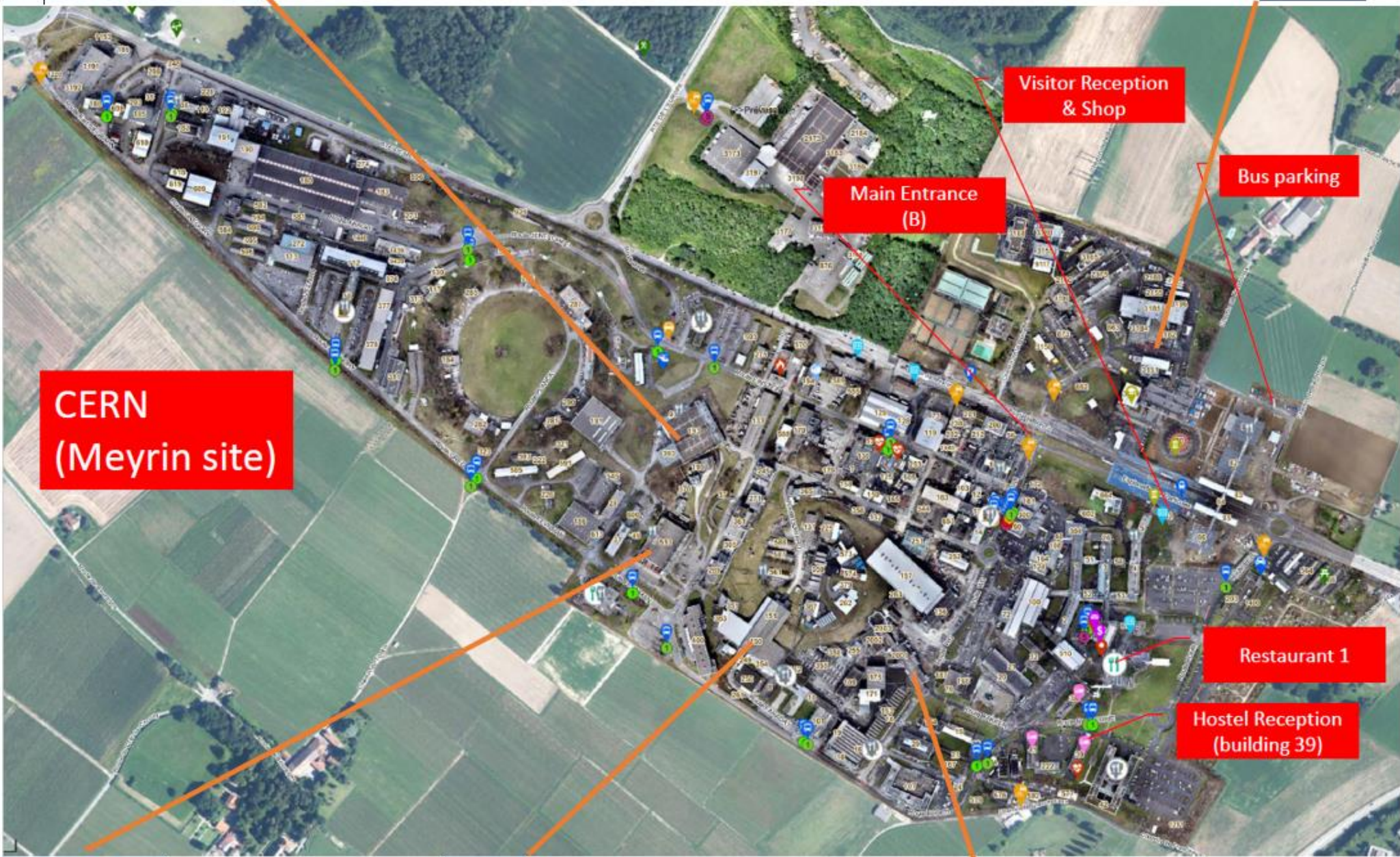
CERN
(Meyrin site)

downtown
Geneva

tram 18 (25 mins)

ANTIMATTER FACTORY

ATLAS



CERN
(Meyrin site)

Visitor Reception
& Shop

Main Entrance
(B)

Bus parking

Restaurant 1

Hostel Reception
(building 39)

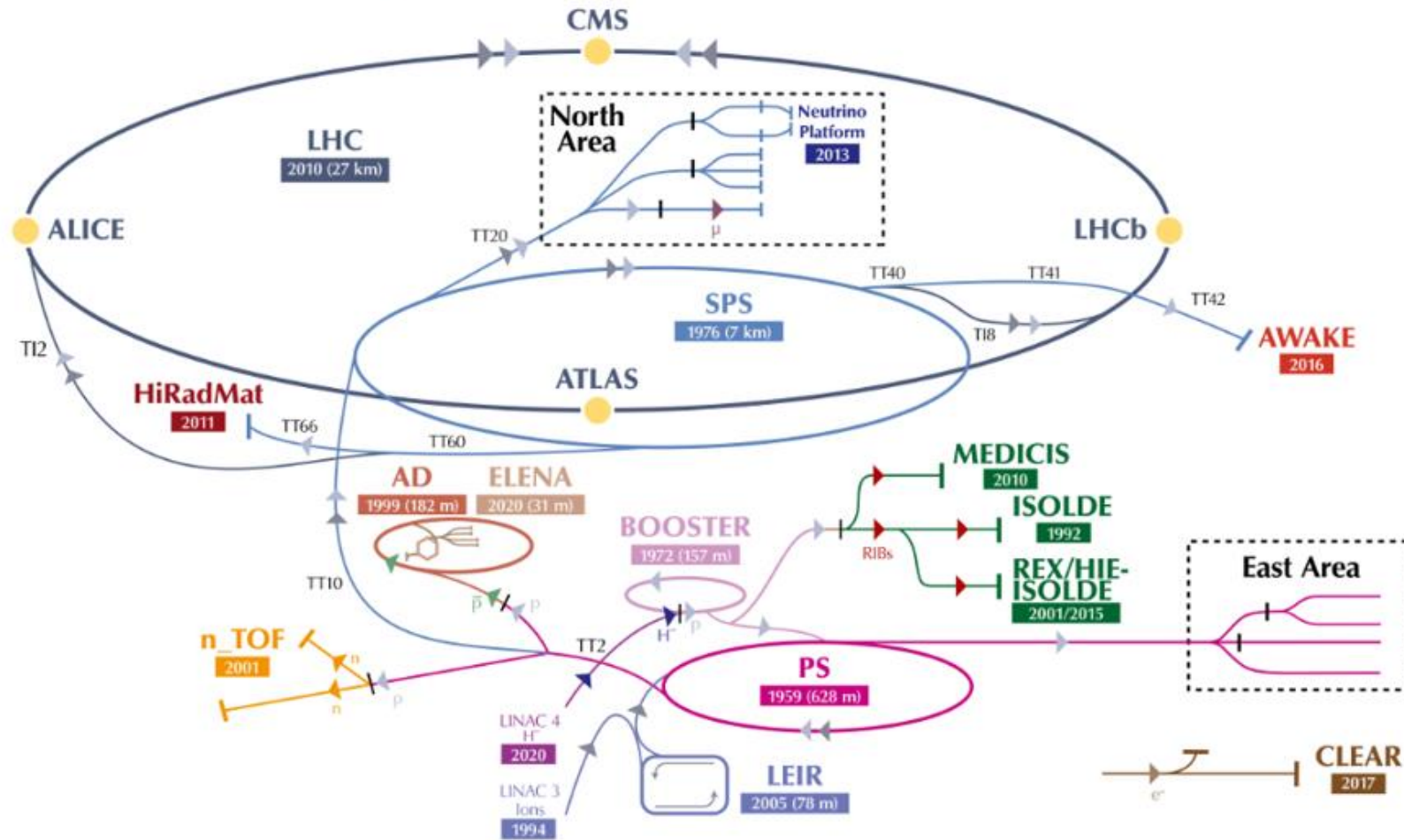
DATA CENTRE

LEIR

CLIC SHOWROOM

The CERN accelerator complex

Complexe des accélérateurs du CERN

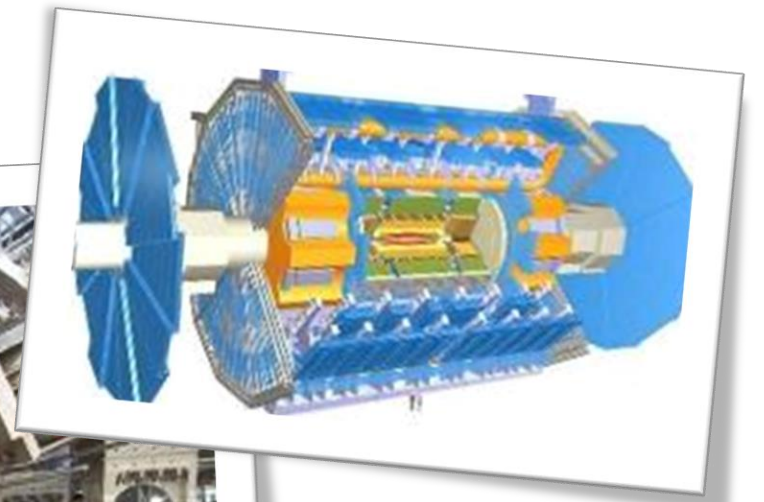
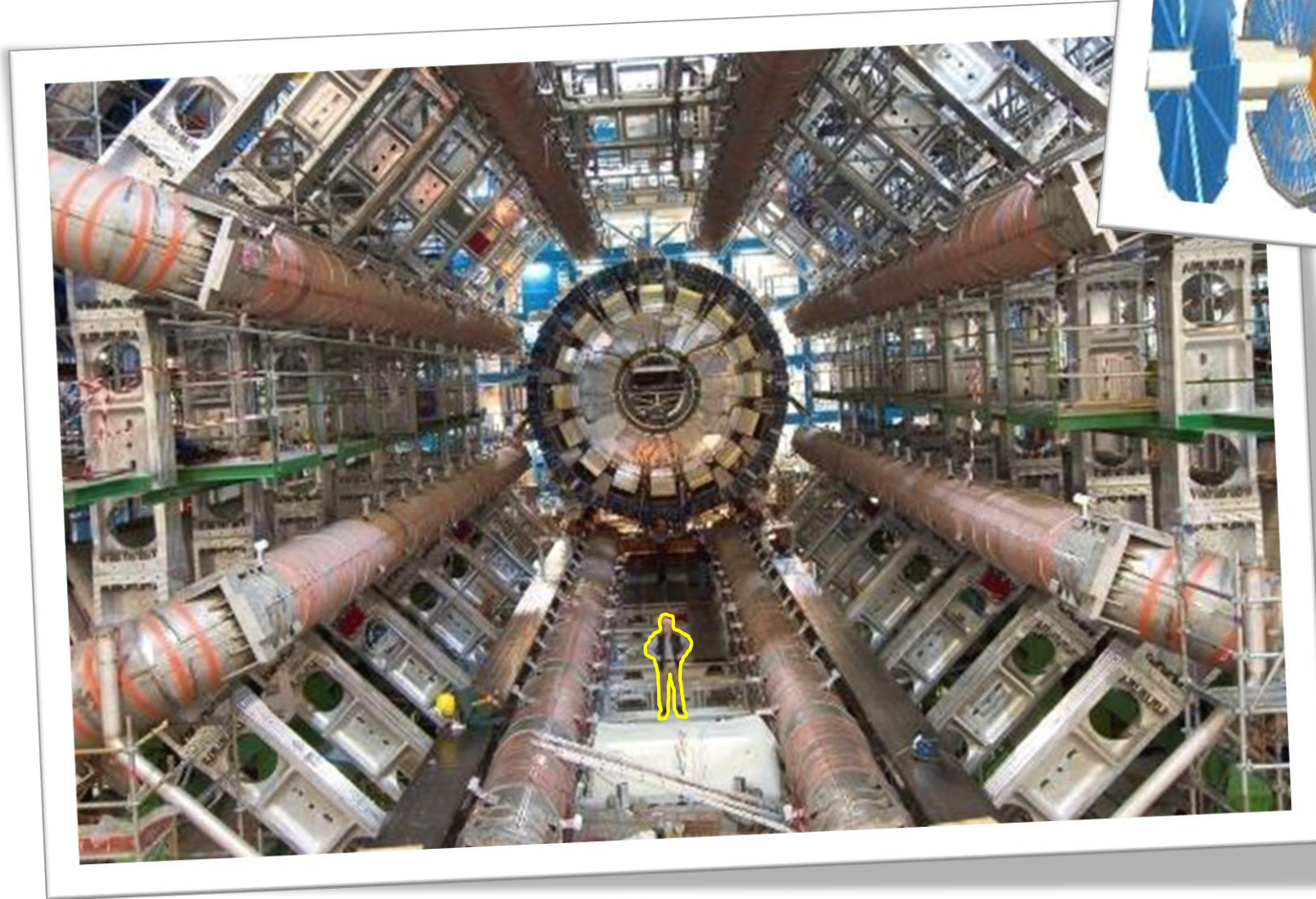


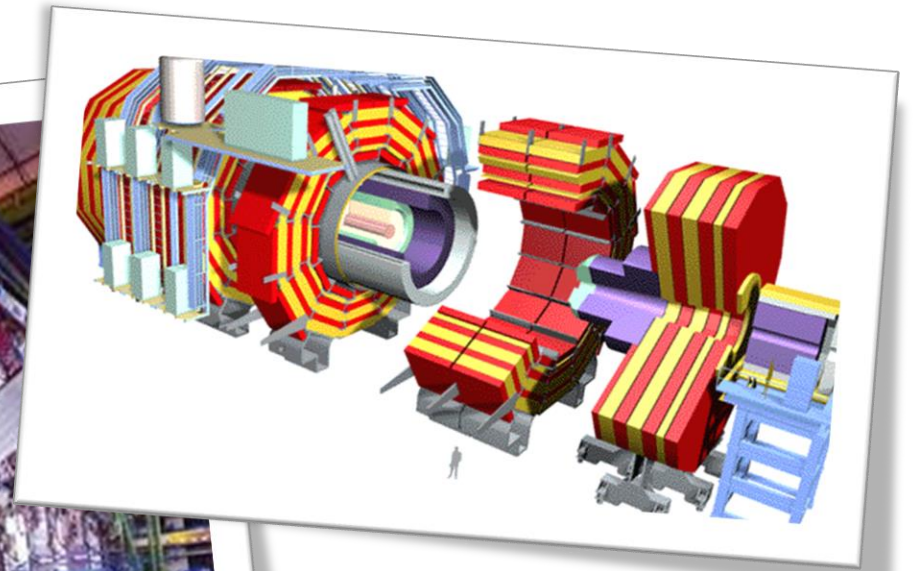
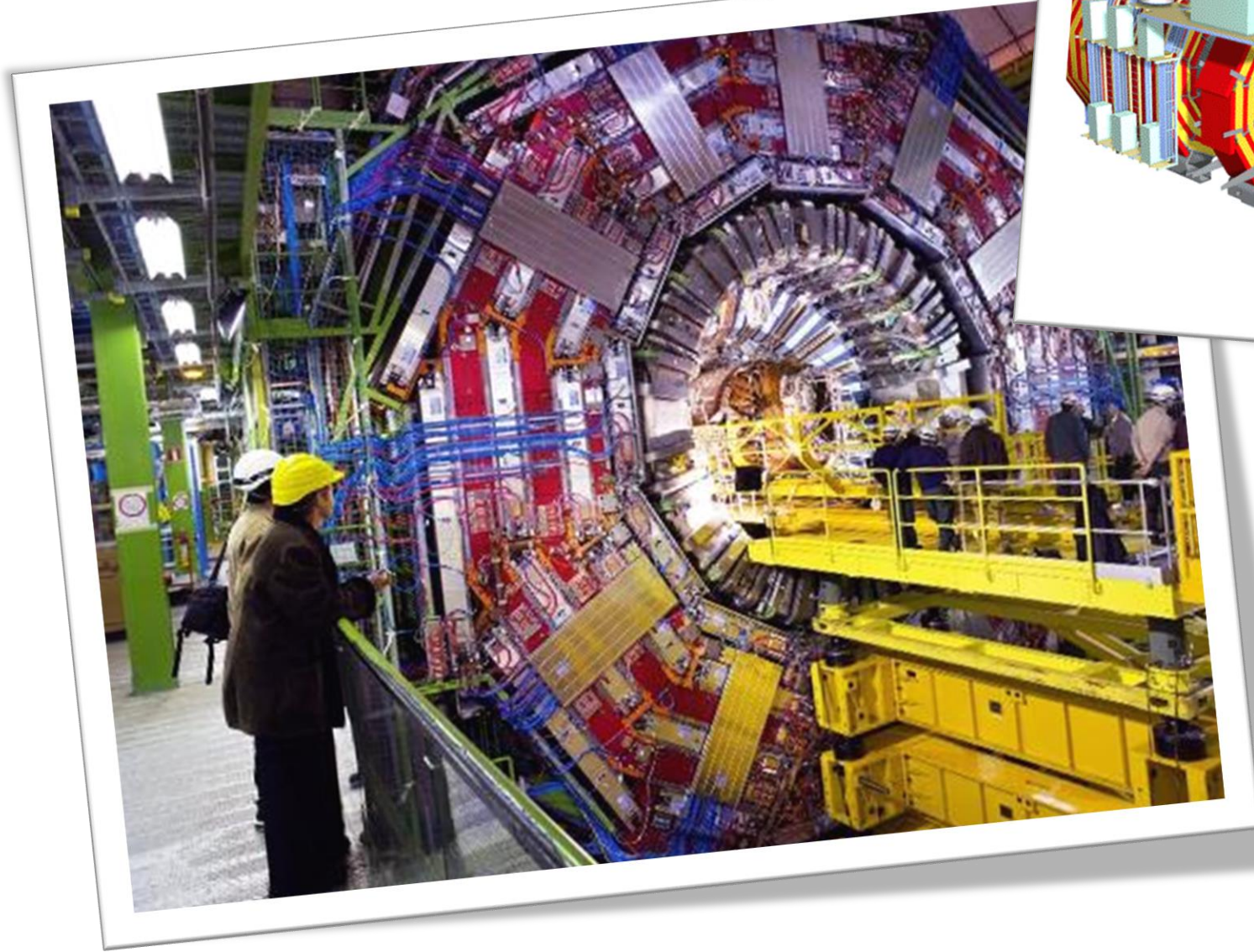
▶ H^- (hydrogen anions) ▶ p (protons) ▶ ions ▶ RIBs (Radioactive Ion Beams) ▶ n (neutrons) ▶ \bar{p} (antiprotons) ▶ e^- (electrons) ▶ μ (muons)

LHC - Large Hadron Collider // SPS - Super Proton Synchrotron // PS - Proton Synchrotron // AD - Antiproton Decelerator // CLEAR - CERN Linear Electron Accelerator for Research // AWAKE - Advanced WAKEfield Experiment // ISOLDE - Isotope Separator OnLine // REX/HIE-ISOLDE - Radioactive Experiment/High Intensity and Energy ISOLDE // MEDICIS // LEIR - Low Energy Ion Ring // LINAC - LINear ACcelerator // n_TOF - Neutrons Time Of Flight // HiRadMat - High-Radiation to Materials // Neutrino Platform

ATLAS

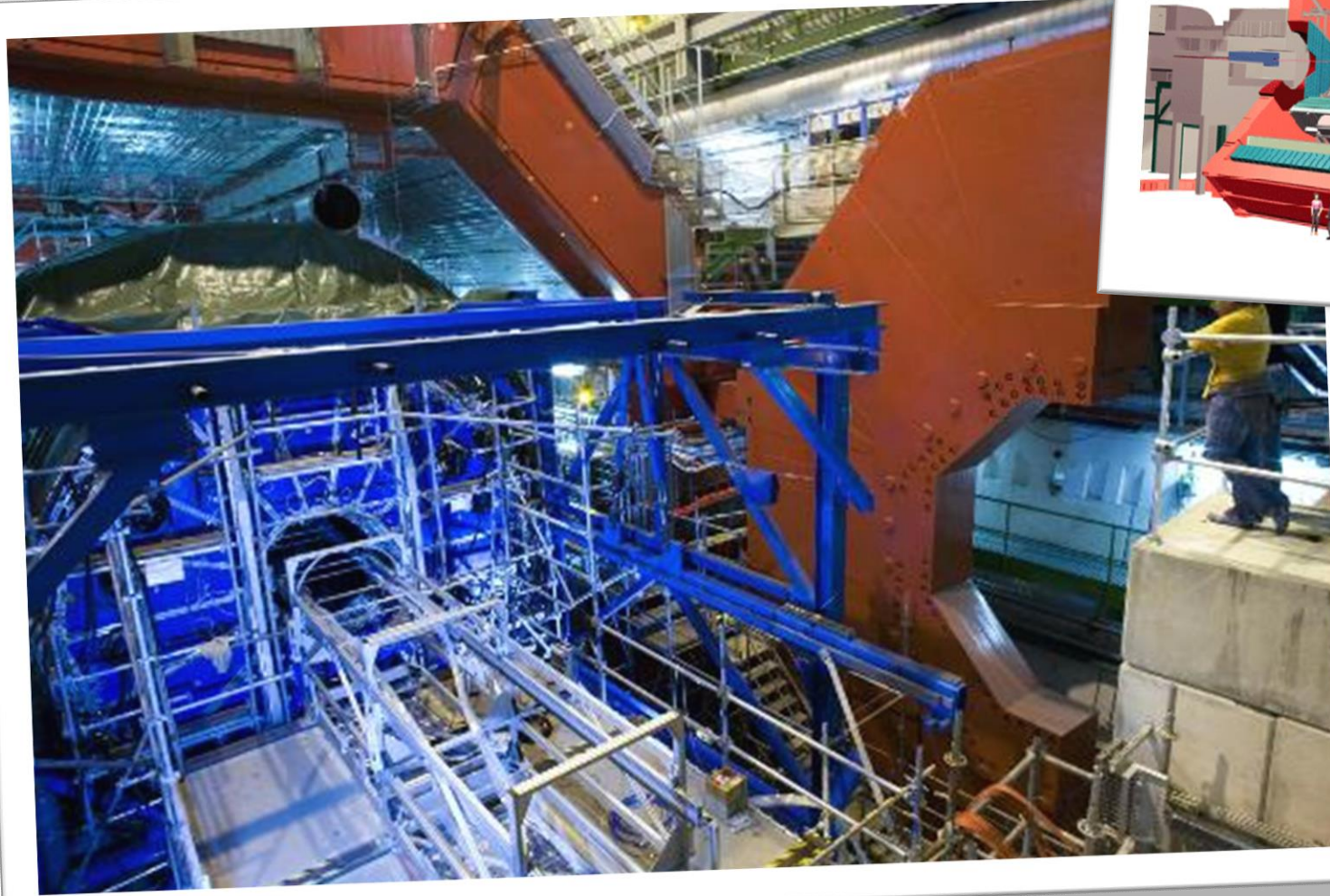
A Toroidal LHC ApparatuS

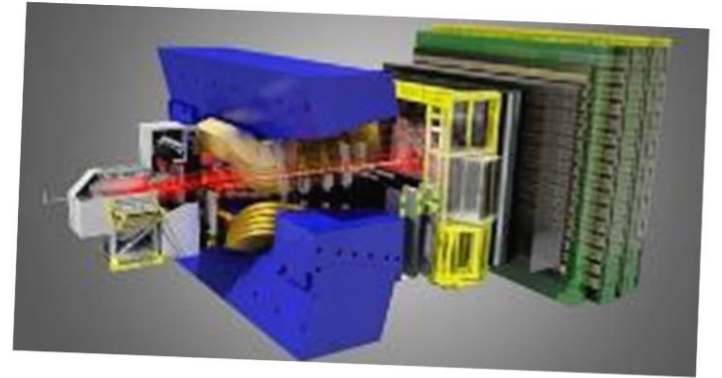
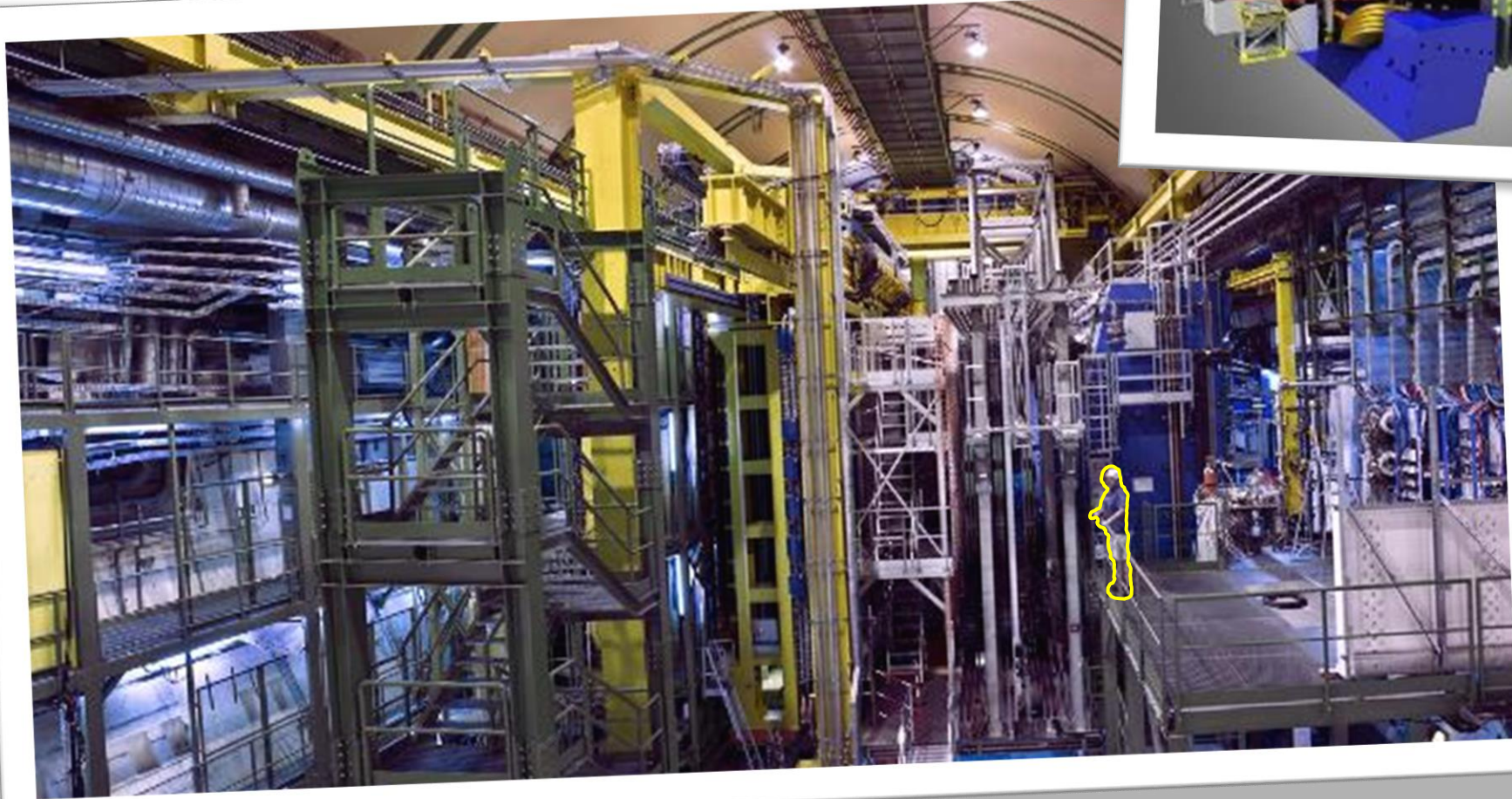




ALICE

A Large Ion Collider Experiment





„Die Mission“

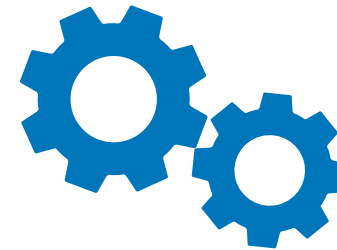
Grundlagenforschung

an der Grenze des menschlichen Wissens

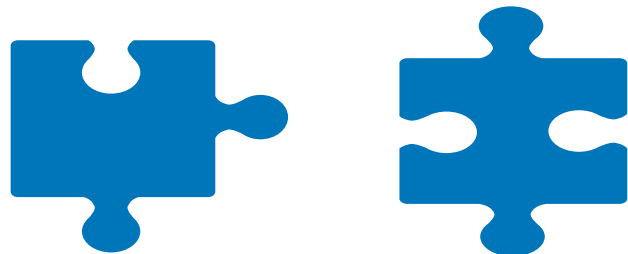


Innovative Technologien

für die Forschung

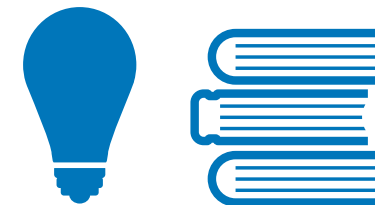


Zusammenarbeit

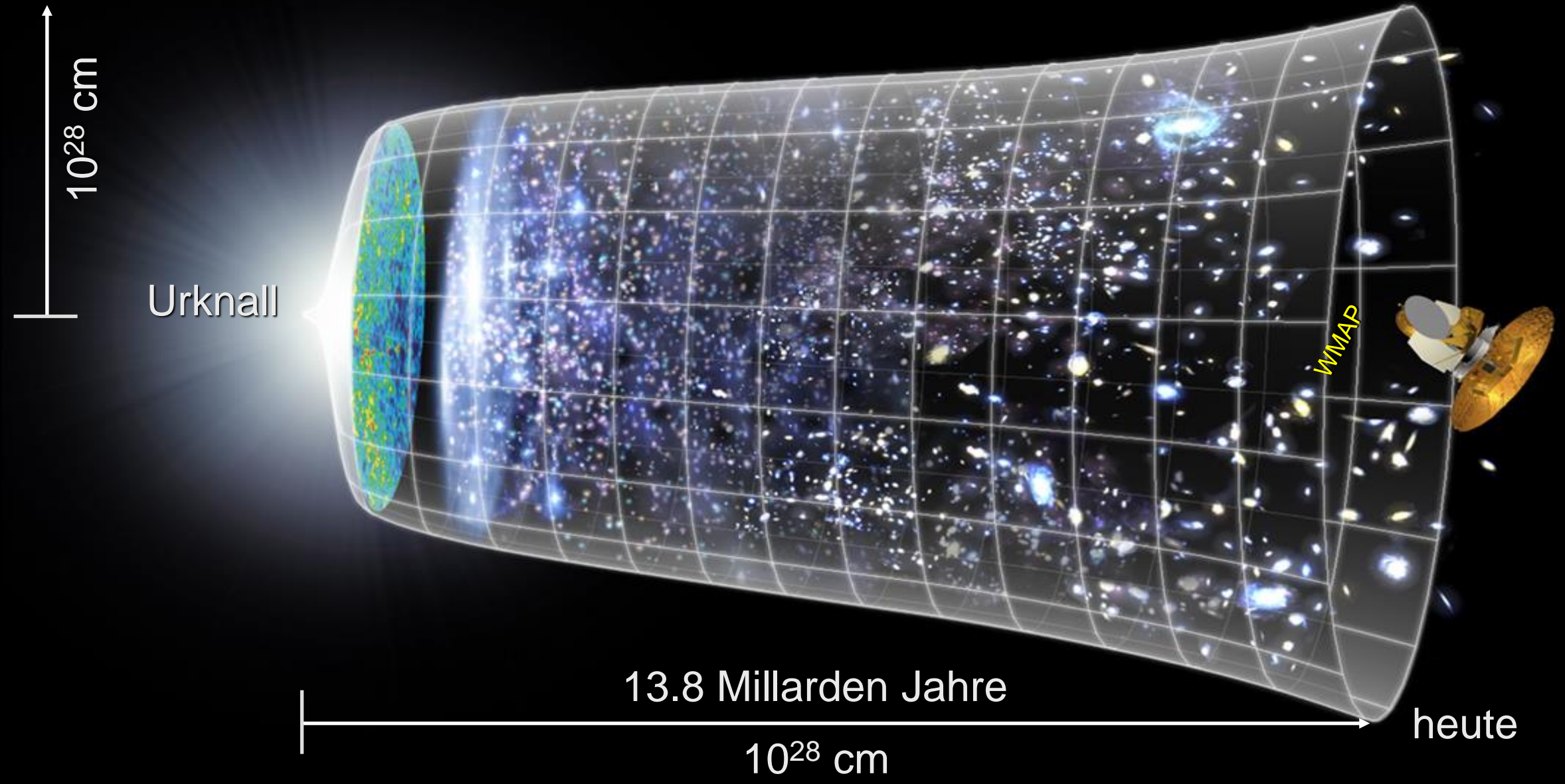


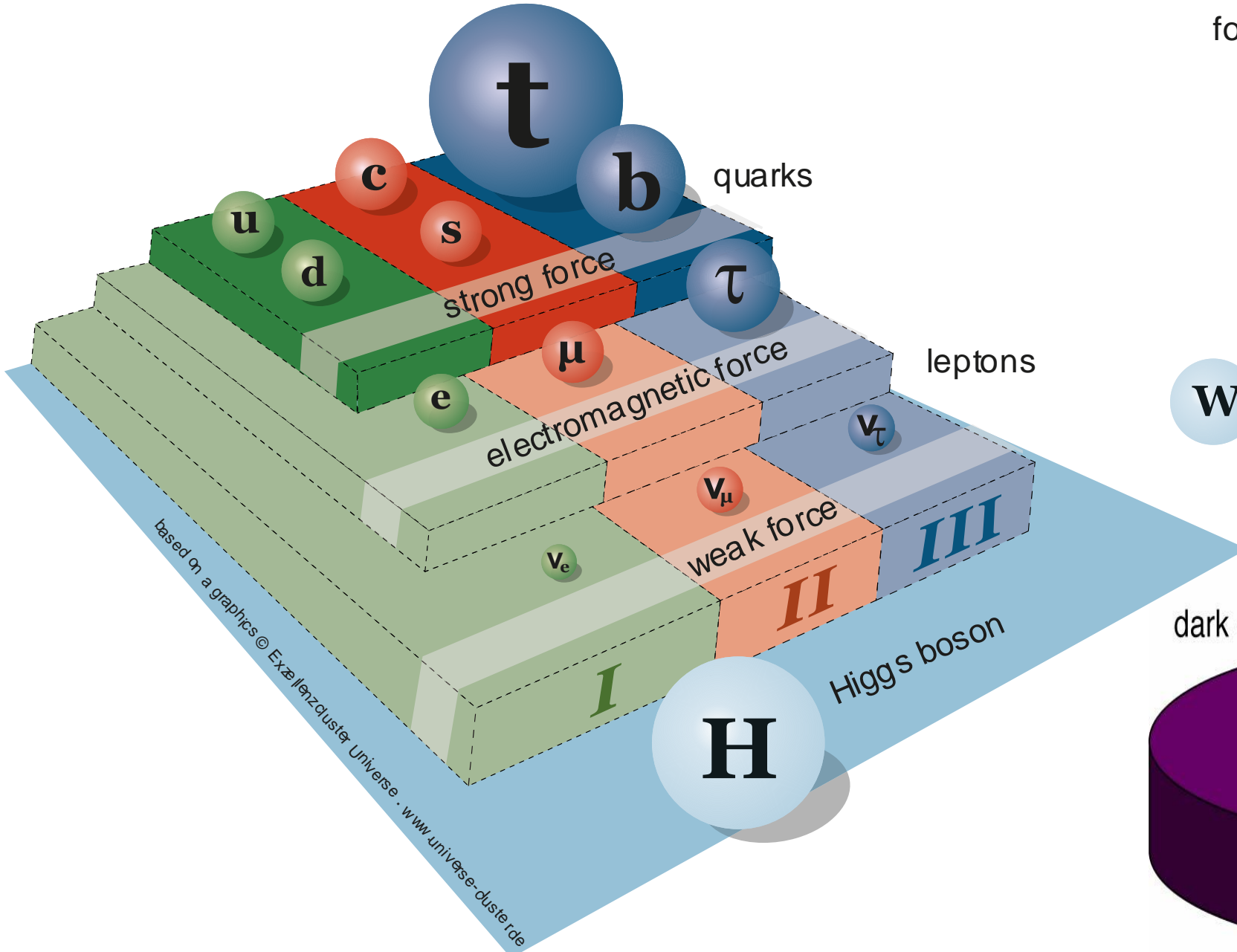
Bildung und Wissensvermittlung

u.a. die Aus- und Weiterbildung von Wissenschaftler(inne)n und Ingenieur(inne)n.
aber eben auch Bildungsprogramme für Alle

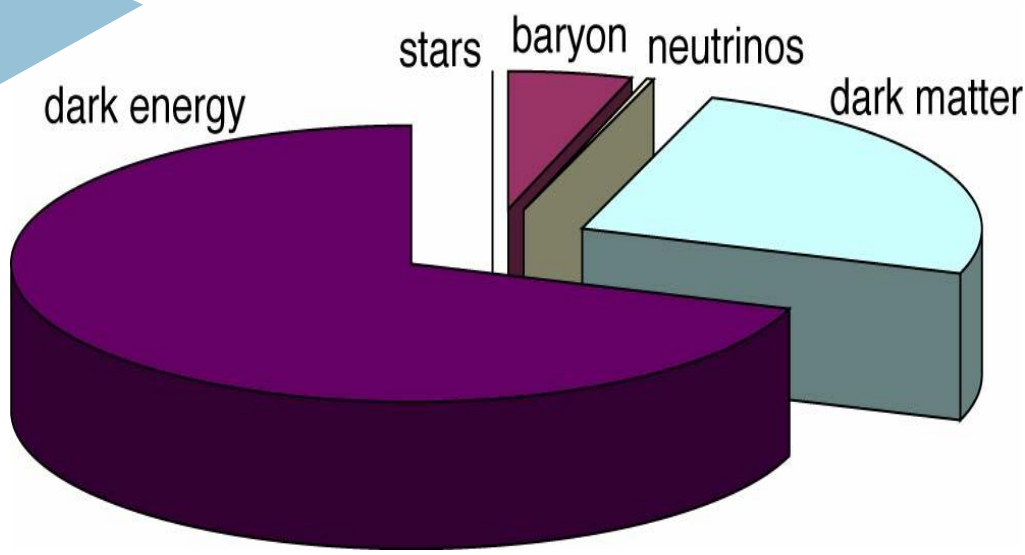
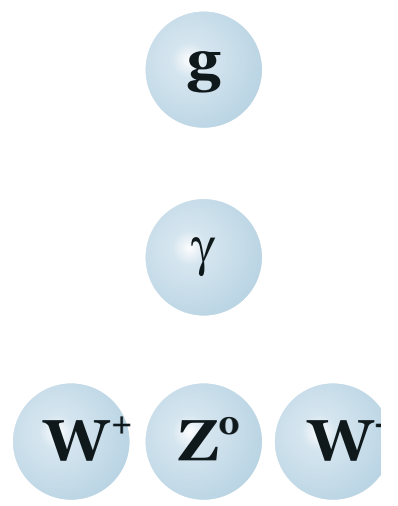


Die Wissenschaftliche Herausforderung Forschung über die Geschichte des Universums





force carriers

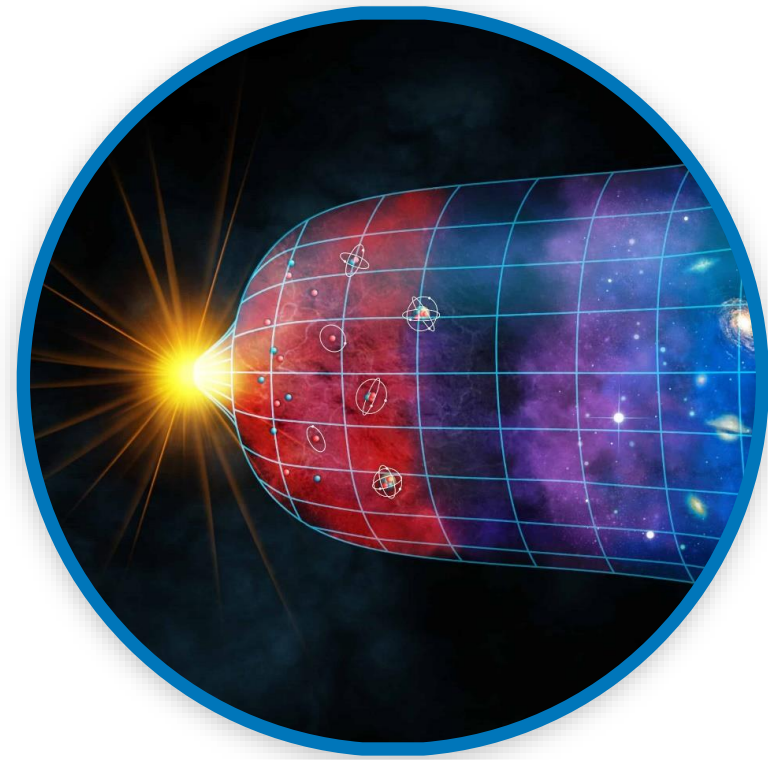


weitere Forschungsfragen

das frühe Universum

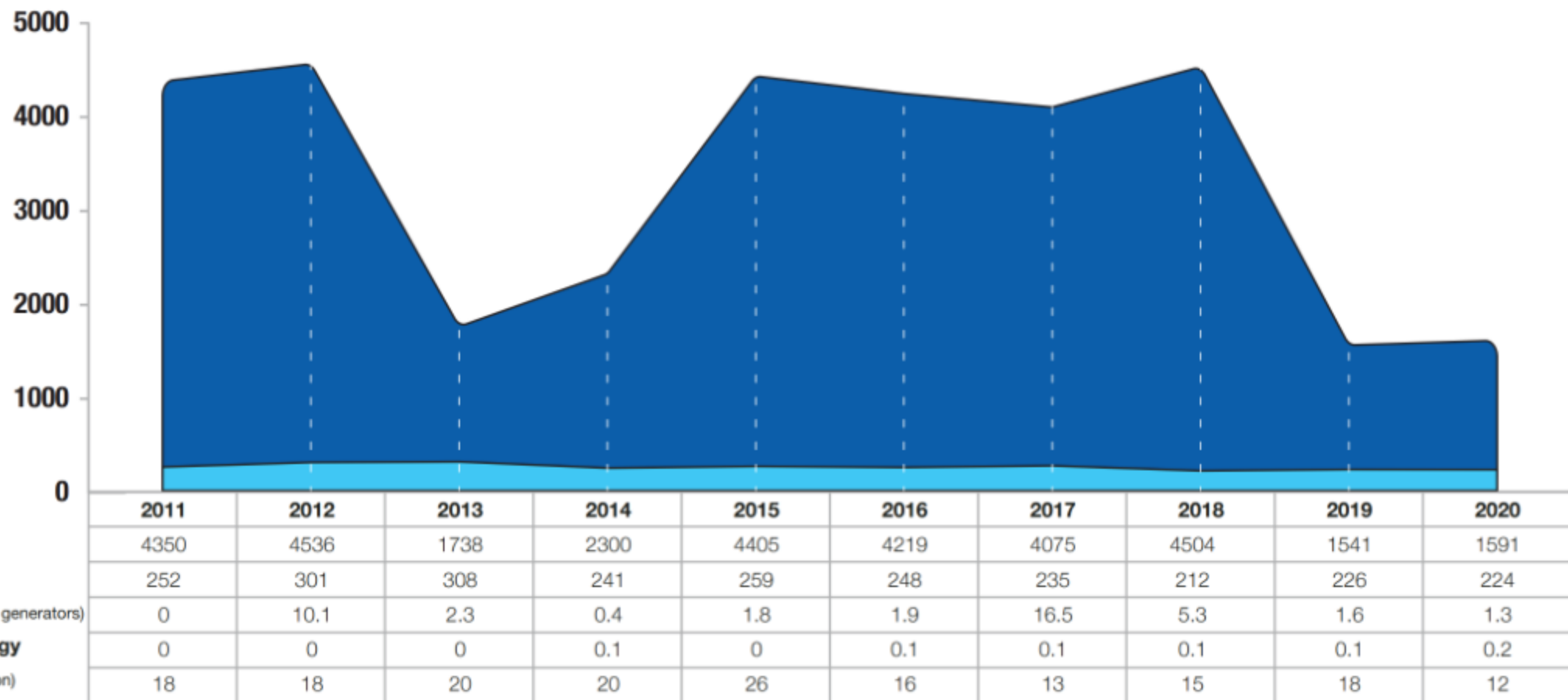
Antimaterie

Dunkle Materie

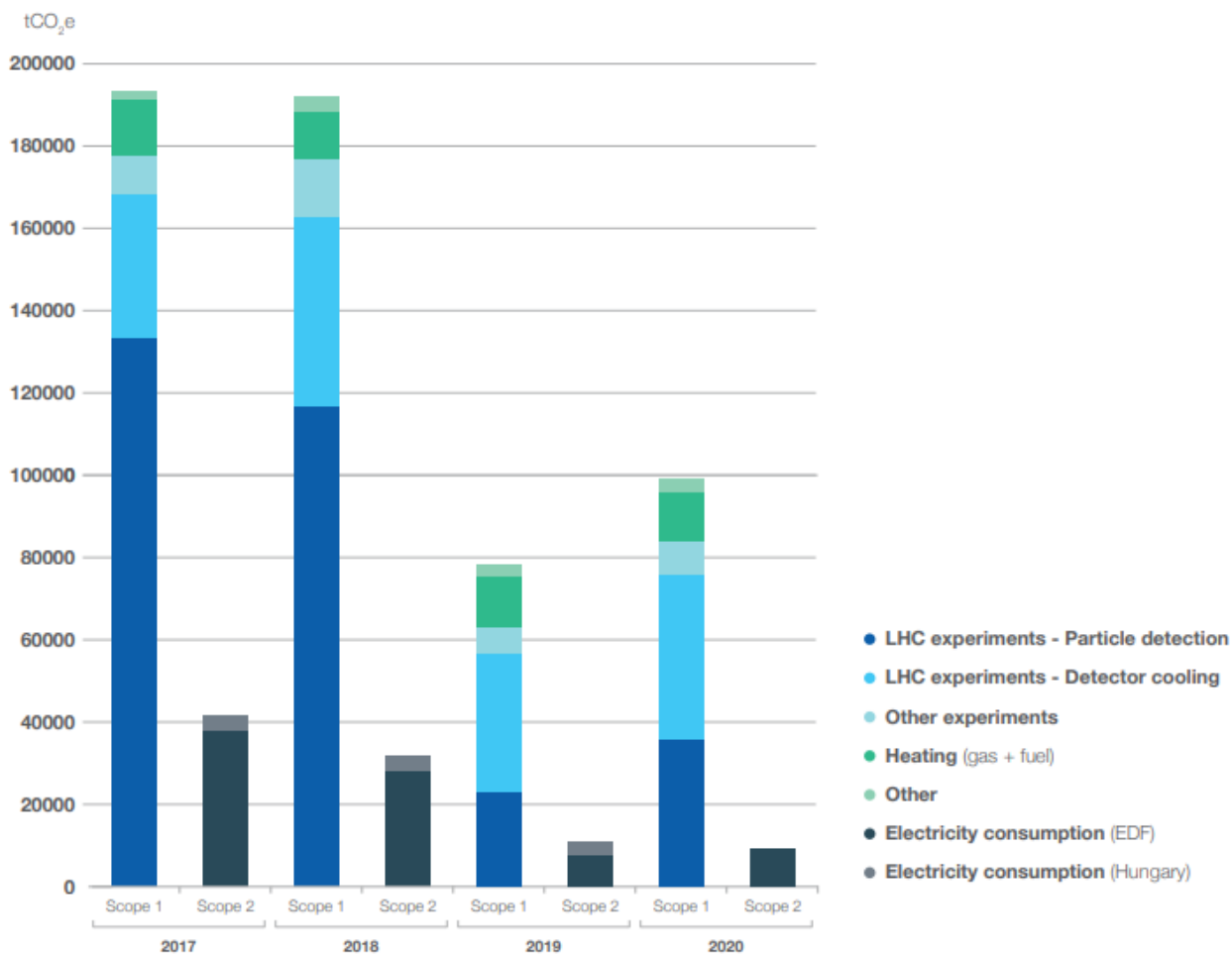


Kosten für unsere Gesellschaft (und unseren Planeten)?

Terajoule (TJ)

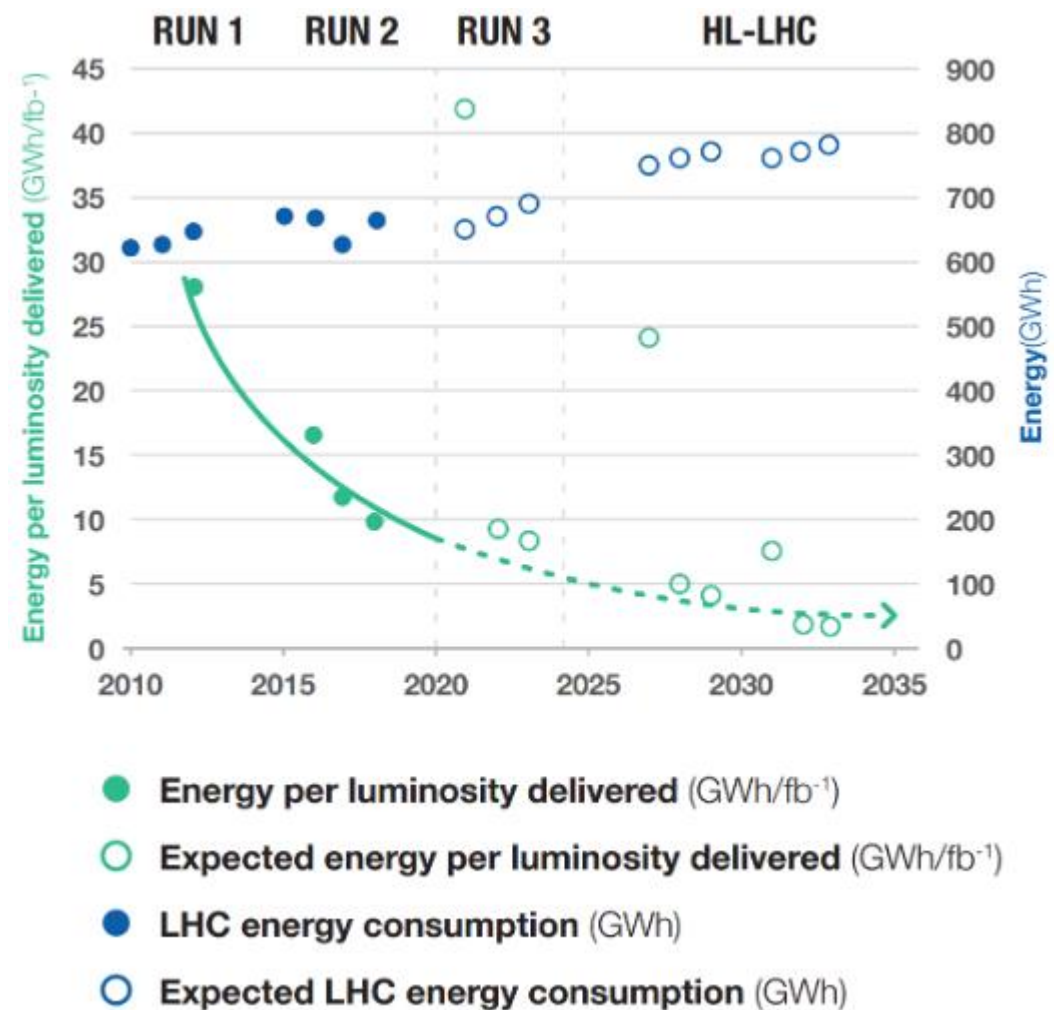


CERN'S ENERGY CONSUMPTION 2011-2020. This does not include the energy consumed at the Wigner Data Centre in Hungary (2011-2019).



CERN SCOPE 1 AND SCOPE 2 EMISSIONS FOR 2017-2020 BY CATEGORY.

Other includes air conditioning, electrical insulation, emergency generators and CERN vehicle fleet fuel consumption. Emission factors for electricity: EDF Bilan des émissions de GES 2002-2020 for EDF and Bilan Carbone® V8 for Hungary.

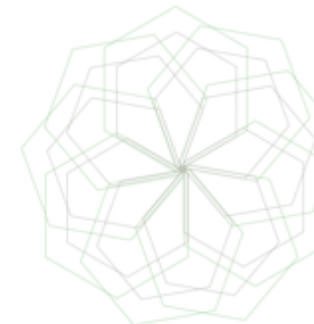
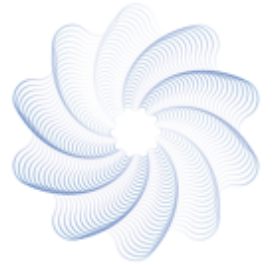


CERN & the environment



I believe CERN should become a role model for an environmentally-aware scientific research laboratory.

- Environment is at the heart of CERN's priorities and future goals.
- CERN strives to be a role model for transparent and environmentally responsible research.
- Reporting on a range of indicators in an open and transparent way, defining ambitious and realistic goals
- Key documents:
 - First environment report: 2017 - 2018
 - Second report: 2019 – 2020
 - Third report: 2021-2022 (in preparation)
 - CERN Masterplan 2040
 - Concrete plans for the future development of the site (mobility, land use, green space management etc.)



<https://hse.cern/environment-report> <https://sce-dep.web.cern.ch/knowledge-center/masterplan-2040>

Environmental Strategy: 3 pillars



Minimise the impact of the laboratory's activities on the environment with defined priority actions



Focus on energy:
consume less, improve efficiency, and recover more
ISO 50001 certified since Feb. 2023



Identifying and developing CERN technologies that would help mitigate society's impact on the environment

Gewinn für unsere Gesellschaft?



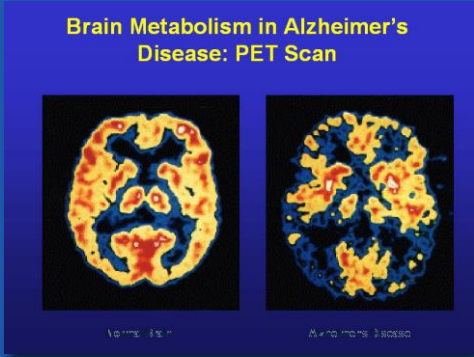
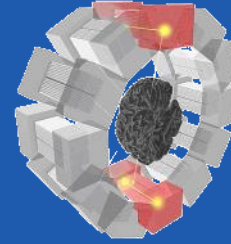
Particle Detection

Imaging

ClearPEM



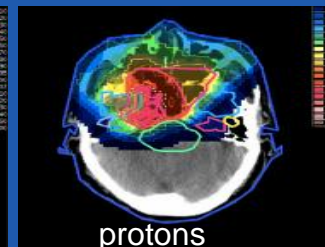
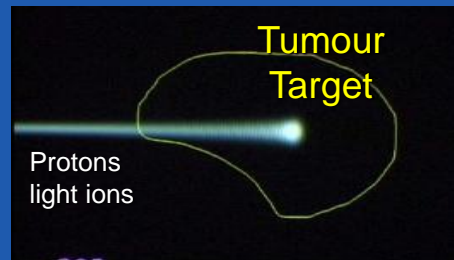
PET Scanner



Accelerated Particle Beams

~30'000 accelerators world-wide
~17'000 for medical applications

Hadron Therapy



>70'000 patients/a world-wide (30 institutes)
>21'000 patients/a in Europe (9 institutes)



Medical Applications

World Wide Web

WWW



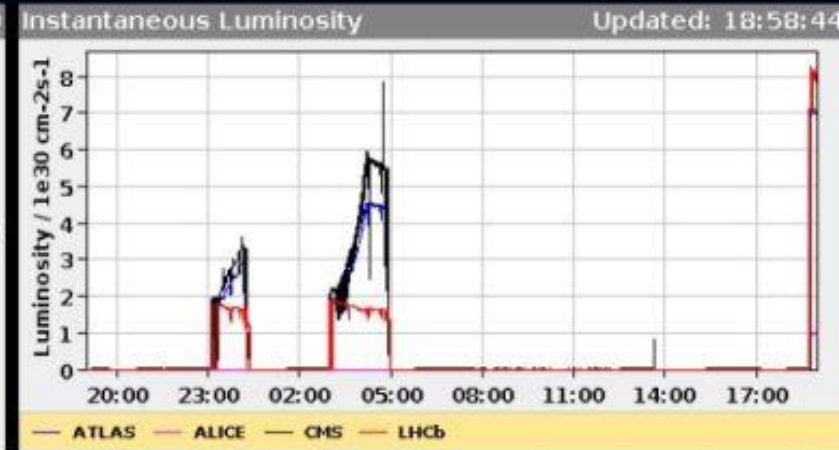
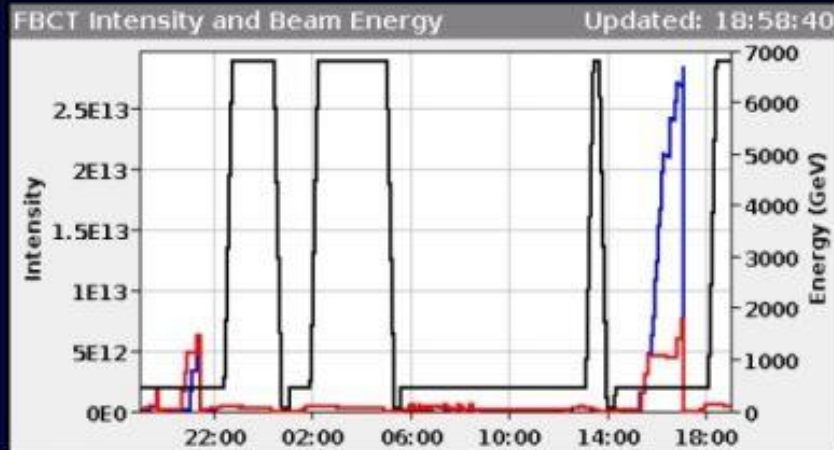
Was passiert gerade?

PROTON PHYSICS: STABLE BEAMS

Energy: 6800 GeV I B1: 4.00e+11 I B2: 4.03e+11

Beta* IP1: 1.20 m Beta* IP2: 10.00 m Beta* IP5: 1.20 m Beta* IP8: 2.00 m

Inst. Lumi [(ub.s)⁻¹] IP1: 6.98 IP2: 0.97 IP5: 7.90 IP8: 7.86



Comments (21-Apr-2023 18:58:40)

First STABLE BEAM at 6.8 TeV
of 2023!

AFS: Single_3b_2_2_2

BIS status and SMP flags

B1

B2

Link Status of Beam Permits

true

true

Global Beam Permit

true

true

Setup Beam

false

false

Beam Presence

true

true

Moveable Devices Allowed In

true

true

Stable Beams

true

true

PM Status B1

ENABLED

PM Status B2

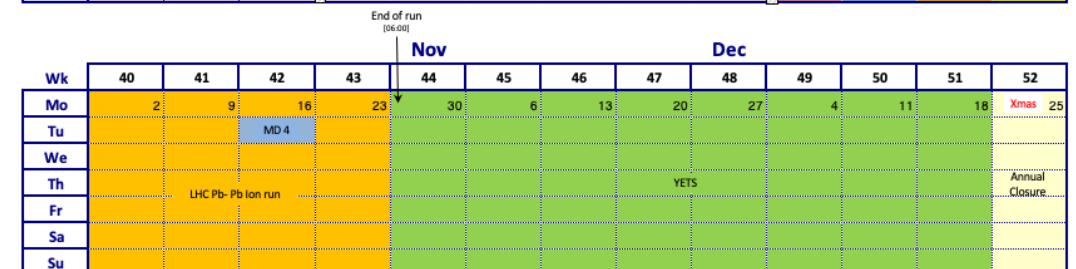
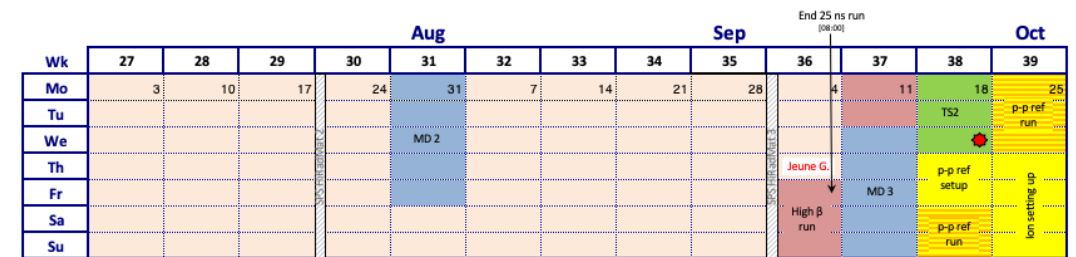
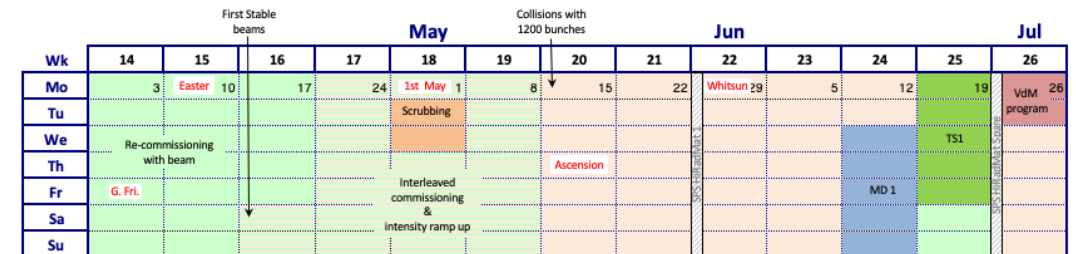
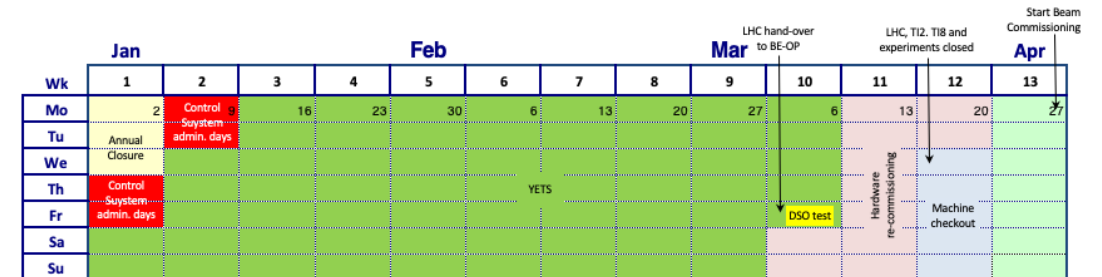
ENABLED



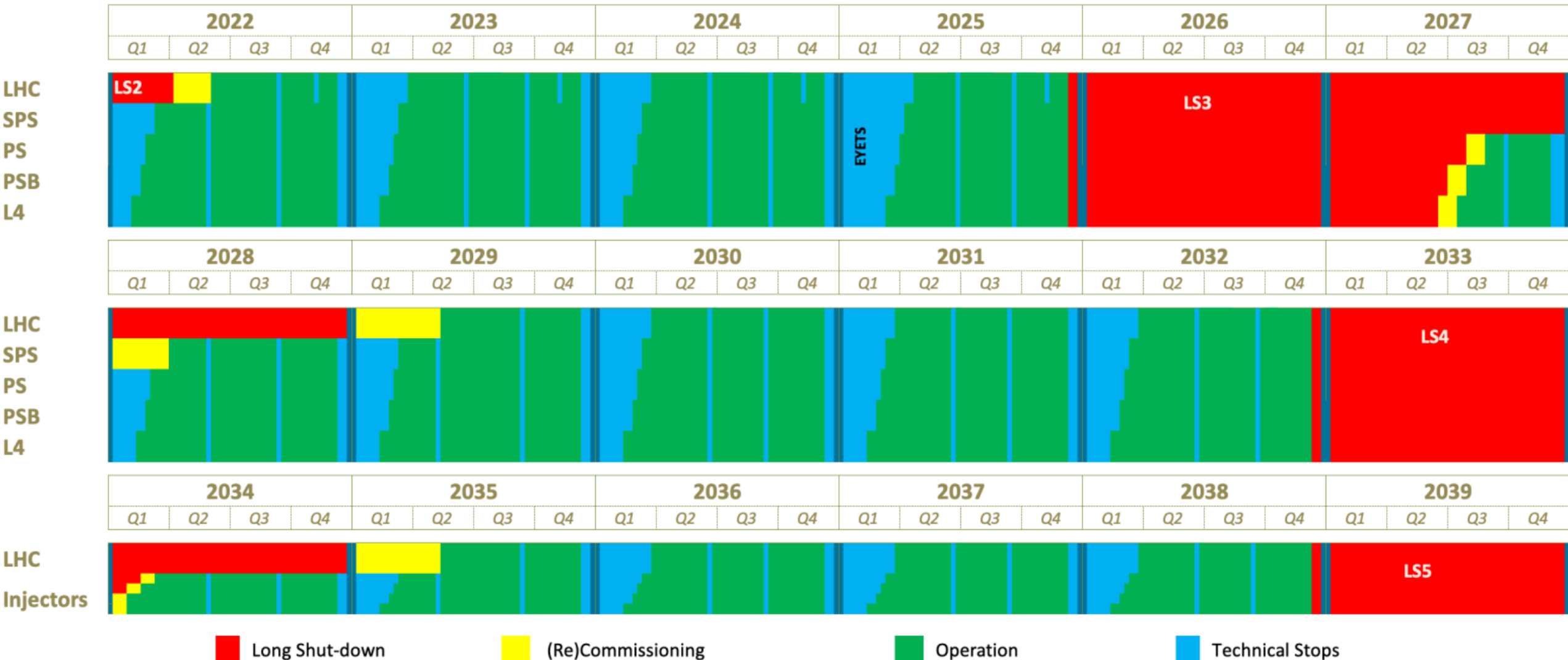
Recently at CERN

The 2023 Draft LHC Schedule in Numbers

Activity	Duration [days]	Ratio [%]
Beam Commissioning & Intensity ramp-up	47	21.7
Scrubbing	2	0.9
25 ns physics (>1200 bunches)	97	44.7
Special physics runs (incl. setting-up)	7	3.2
Pb-Pb ions & p-p ref. setting-up	6	2.8
Pb-Pb ions physics & p-p ref. run	32	14.7
Technical stop	8	3.7
Technical stop recovery	2	0.9
Machine Development blocks (incl. floating MDs)	16	7.4
Total:	217	100%



Long Term Schedule for CERN Accelerator complex

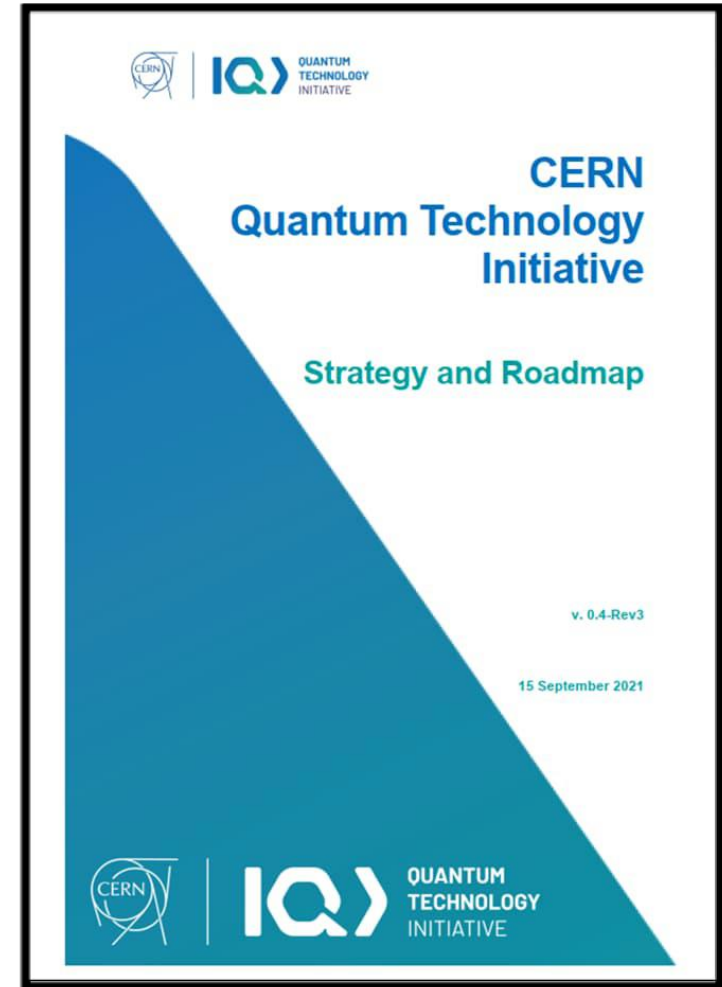


CERN Quantum Technology Initiative

Established in September 2020

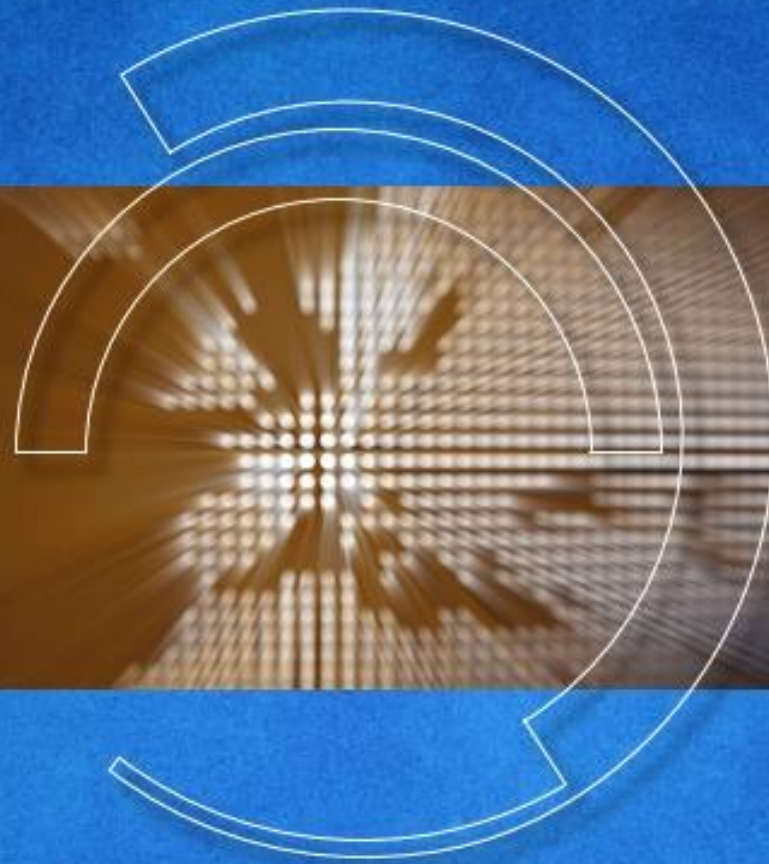
Achievements in 2021:

- **Setting up the initiative and its governance**
 - Coordination Task Force, Advisory Board, Web site, comms channels, branding, awareness
- **Projects and PhD programme**
 - Research programme as part of CERN DOCT programme
 - Research collaborations with institutes in the Member States and beyond (17 ongoing projects)
- **Infrastructure**
 - Local classic cluster for quantum computing simulations, a dedicated simulator, and access to quantum hardware from different providers
- **Strategy and Roadmap**
 - Developed in discussions with the CERN community, the Advisory Board and experts from the HEP/quantum communities, published in September 2021



<https://doi.org/10.5281/zenodo.5553774>

Und dann?



2020 UPDATE OF THE EUROPEAN STRATEGY
FOR PARTICLE PHYSICS

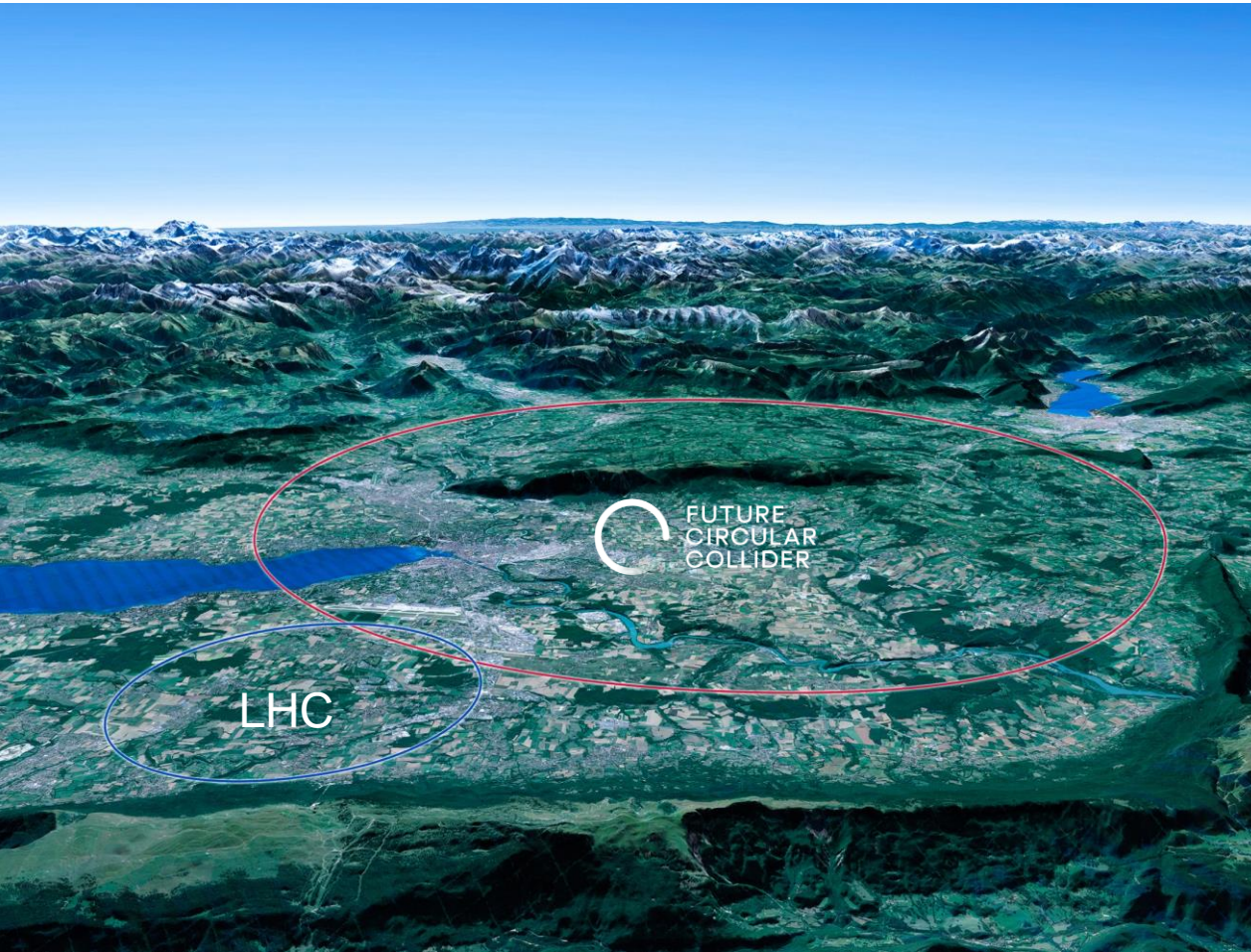
by the European Strategy Group



CERN Scientific Priorities for the Future

Implementation of the recommendations of the **2020 Update of the European Strategy for Particle Physics:**

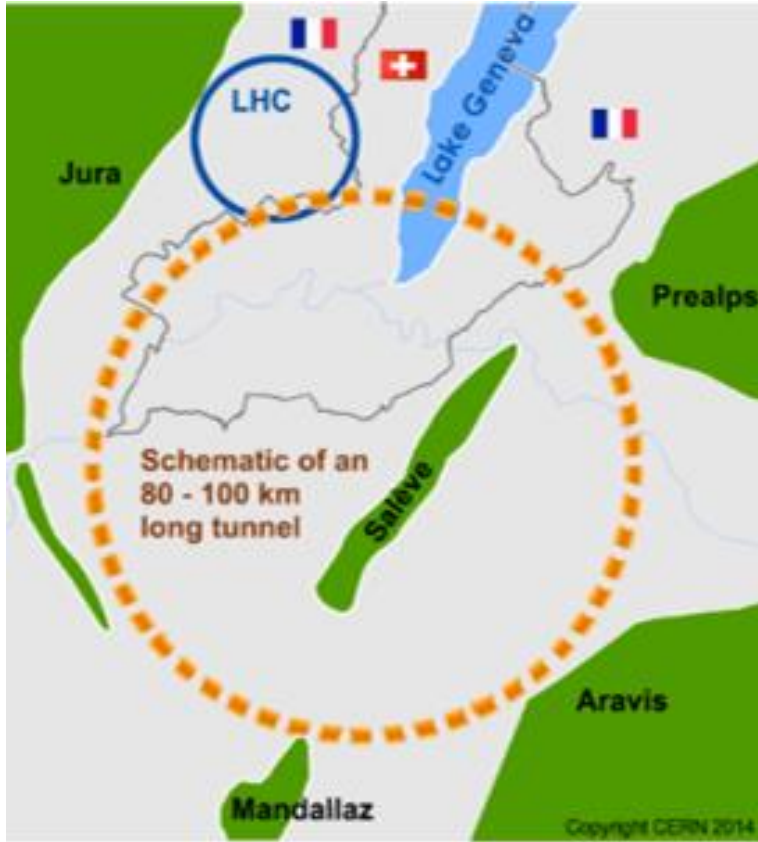
- Fully exploit the LHC & HL-LHC.
- Build a Higgs factory to further understand this unique particle.
- Investigate the technical and financial feasibility of a future energy-frontier 100 km collider at CERN.
- Ramp up relevant R&D.
- Continue supporting other projects around the world.



The FCC Integrated Programme

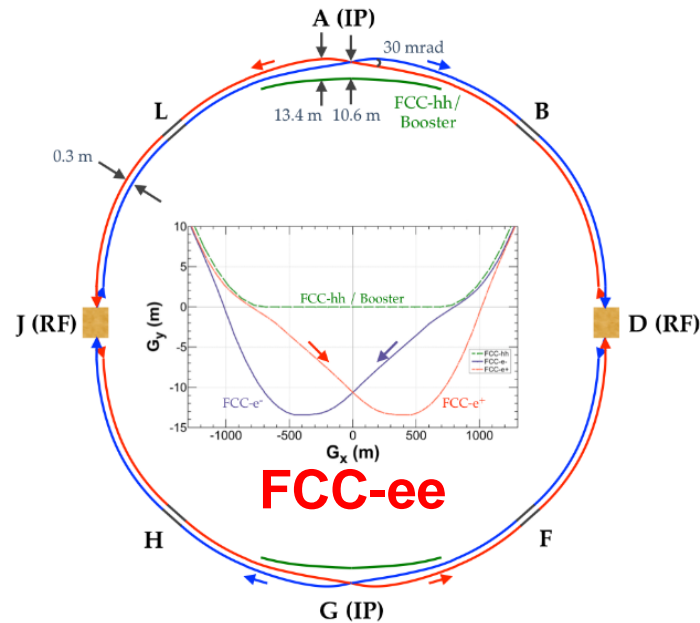
Inspired by successful LEP – LHC Programmes at CERN

Complementary physics, common civil engineering and technical infrastructures, building on and reusing CERN's existing infrastructure, FCC integrated project allows seamless continuation of HEP after HL-LHC



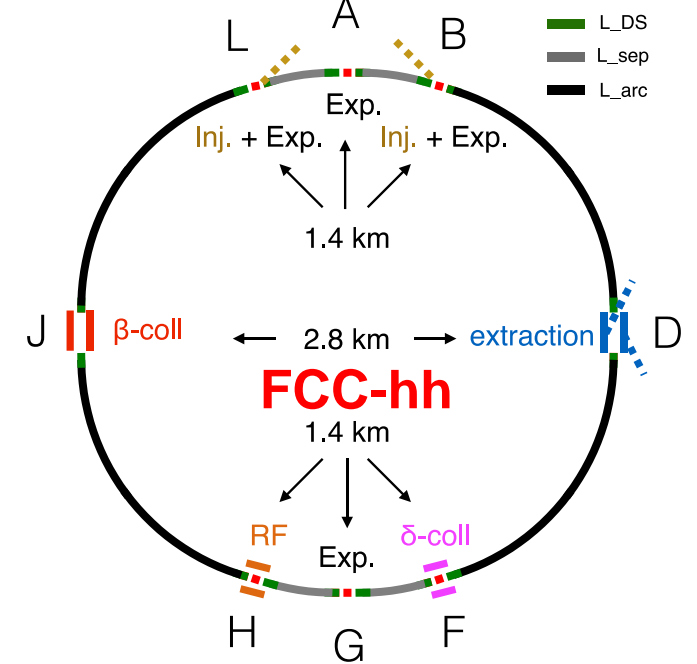
2020 - 2040

Phase 1 : FCC-ee
electron – positron Collider
Higgs, Z, W, ttbar Factory at highest lumi



2040 - 2055

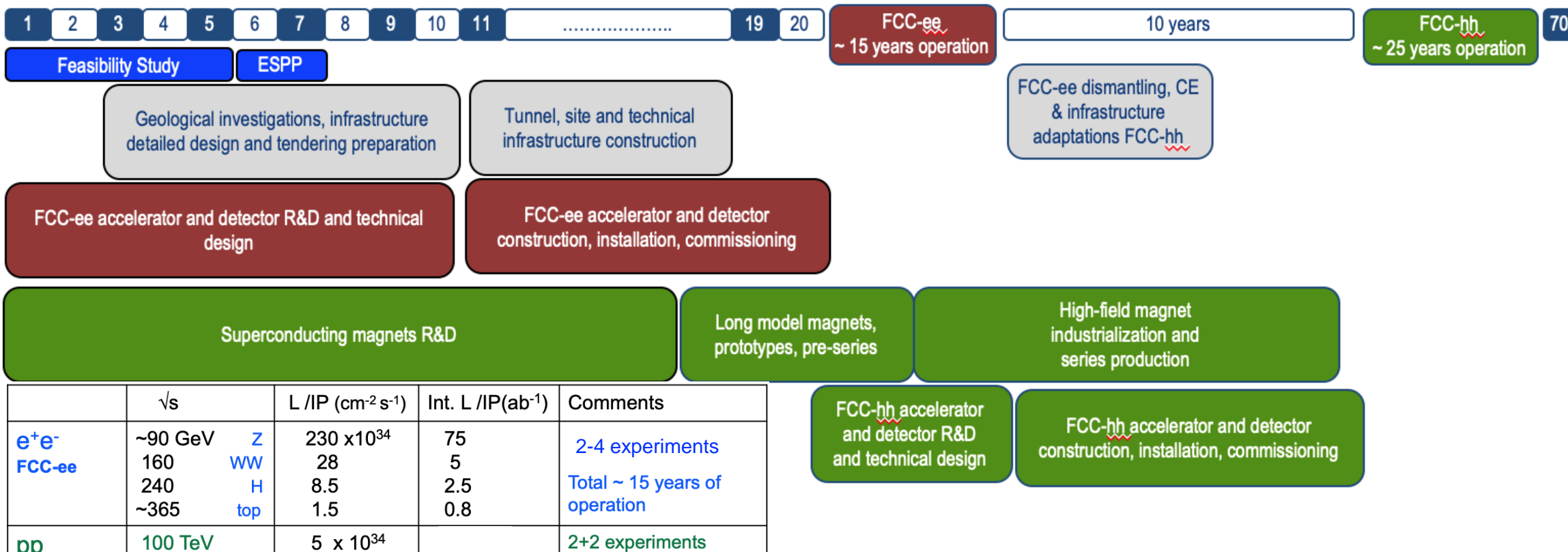
Phase 2 : FCC-hh
proton – proton Collider
High-energy frontier (pp, ion, eh)



2060 - 2090

Timeline of the FCC Integrated Programme

Technical
schedule



	\sqrt{s}	L /IP (cm ⁻² s ⁻¹)	Int. L /IP(ab ⁻¹)	Comments	
e⁺e⁻ FCC-ee	~90 GeV 160 240 ~365	Z WW H top	230 x 10 ³⁴ 28 8.5 1.5	75 5 2.5 0.8	2-4 experiments Total ~ 15 years of operation
pp FCC-hh	100 TeV	5 x 10 ³⁴ 30	20-30	2+2 experiments Total ~ 25 years of operation	
PbPb FCC-hh	$\sqrt{s_{NN}} = 39\text{TeV}$	3 x 10 ²⁹	100 nb ⁻¹ /run	1 run = 1 month operation	
ep Fcc-eh	3.5 TeV	1.5 10 ³⁴	2 ab ⁻¹	60 GeV e- from ERL Concurrent operation with pp for ~ 20 years	
e-Pb Fcc-eh	$\sqrt{s_{eN}} = 2.2\text{ TeV}$	0.5 10 ³⁴	1 fb ⁻¹	60 GeV e- from ERL Concurrent operation with PbPb	

- Feasibility Study: 2021-2025
- If project approved before end of decade → construction can start beginning 2030s
- FCC-ee operation ~2045-2060
- FCC-hh operation 2070-2090++

Möglichkeiten am CERN



QUEST
ties – Tertiary and Beyond



ORIGIN

Research Fellowships



The 2021/2022 European School of High-Energy Physics

April 18 - 31 May 2022

Standing Committee

Scientific Programme

Discussion Leaders

Sponsors

International Advisors

Local Committee

https://eshep.cern.ch/indico/2022/

AEPSHEP

Asia Europe Pacific School of High Energy Physics

05-18 OCTOBER 2022

Scientific Programme

Discussion Leaders

Local Committee

CERN School of Computing

4th - 17th September 2022

Kraków - Poland

Physics computing – Software engineering Data Technologies ...and much more!

Two weeks of lectures and hands-on exercises on advanced and challenging computing topics. Rich social programme. For postgraduate engineers or scientists with experience in particle physics, in computing or in related fields.

Deadline for Application: 8 May 2022

<https://indico.cern.ch/e2022>

ISOTDAQ 9th EDITION 2018

INTERNATIONAL SCHOOL OF TRIGGER & DATA ACQUISITION

14-22 FEBRUARY 2018 VIENNA, AUSTRIA

[HTTP://ISOTDAQ.HEPHY.AT](http://isotdaq.hephy.at)

TOPICS

- TRIGGER**: ANALOG ELECTRONICS, PROGRAMMING ELECTRONICS, INTELLIGENT TRIGGERING, ASSOCIATIVE MEMORIES, FPGA PROGRAMMING
- DAQ**: ADC, DAC, DETECTOR READOUT, FIBRE OPTIC CONTROLS, CHANNELS, XY CAL, PCL, PCLX, DATA NETWORKS, EVENT AND BUFFER MANAGEMENT, CSC - IN PROGRAMMING FOR CSD
- APPLICATION EXAMPLES**: GENERAL CONCEPTS OF ISDAQ, RECENT PCL USE CASES, FROM LINUX SYSTEMS

CERN ORGANIZING COMMITTEE

LOCAL ORGANIZING COMMITTEE

HOW TO APPLY

REGISTRATION DEADLINE: 1 NOVEMBER 2017

WEBSITE: [HTTP://ISOTDAQ.HEPHY.AT](http://isotdaq.hephy.at)

Introduction to Accelerator Physics

Victoria Hotel Kaunas, 18 September - 1 October 2022, Kaunas, Lithuania

The final decision on holding this course will be taken by July 2022. Hence previous inscriptions are only a firm expression of interest. Payments and travel organization will be done after the confirmation date.

The introductory CAS course represents the core teaching of all CAS courses and represents the ideal opportunity to be introduced into the field of particle accelerators. This course will be of interest to staff and students from laboratories and universities as well as from companies manufacturing accelerator equipment. The course will focus on various aspects of beam dynamics and it will provide an introduction to the underlying accelerator systems and technologies. Key topics will be consolidated through a series of discussion sessions and computer-based tutorials, while topical seminars will round up the program.

Contact: CERN Accelerator School, CH - 1211 Geneva 23, accelerator.school@cern.ch

14th CERN-FERMILAB HADRON COLLIDER PHYSICS SUMMER SCHOOL

CERN, 28 August - 6 September 2019

MAIN LECTURE TOPICS

International Advisory Committee

Local Organizing Committee

More information at: <http://cern.ch/hccps2019>

10th CERN LATIN-AMERICAN SCHOOL OF HIGH-ENERGY PHYSICS

18-30 March 2019

Scientific Programme

Field Theory and the EW

Special Lecture on Gravitational Waves

Cosmology

Neutrino Physics

Special Lectures

Local Organizing Committee

International Advisory Committee

13th Inverted CERN School of Computing

From 28 September to 2 October 2020 ONLINE SCHOOL

Lectures:

- Programming Paradigms and Design Patterns
- Heterogeneous Programming with OpenCL
- Reconstruction and Imaging
- Computational Fluid Dynamics
- Modern C++ features
- Big Data processing with SQL

Registration and more information: www.cern.ch/csc

Danube School on Instrumentation in Elementary Particle & Nuclear Physics

University of Novi Sad, Serbia, September 8-13, 2014

The school is an equal opportunity event intended for MSC, PhD and Postdoc students who want to acquire hands on experience in different detector technologies used in Particle Physics and Nuclear Physics. Researchers, who are actively involved in the field and are recognized experts in detector R&D, will give lectures and state-of-art laboratory sessions. Students are encouraged to attend, contribute and share their experience.

Review Talks

- Higgs Boson: from QED to LHC
- Future Challenges in Physics
- The Linear Colliders Challenges
- Neutrino Physics
- The Challenge of B-physics and rare decay events
- Astro-particle and dark matter searches
- Nuclear Physics

International Advisory Committee

Local Organizing Committee

More information and registration: <http://cern-danube-school.uns.ac.rs>

Deadline for applications: June 15th 2014

The CERN Accelerator School is organizing the next general course on ADVANCED ACCELERATOR PHYSICS

06 - 18 November 2022 Neaclub, Sévrier, France

The course will be of interest to physicists and engineers who wish to extend their knowledge on accelerator physics and technologies and expand their professional network.

The course offers core lectures in the mornings combined with hands-on-tutorial in the afternoons. Participants will be able to select one afternoon course from the following three: RF-measurements, beam instrumentation, and beam optics design.

Contact: CERN Accelerator School, CH - 1211 Geneva 23, accelerator.school@cern.ch

Future Circular Collider at CERN

Emmanuel Tsesmelis

17 PARTNERSHIPS FOR THE GOALS

4 QUALITY EDUCATION

„Die Mission“

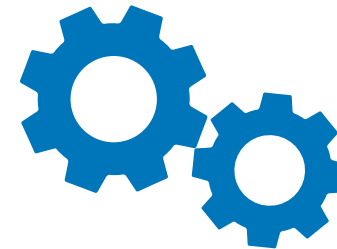
Grundlagenforschung

an der Grenze des menschlichen Wissens

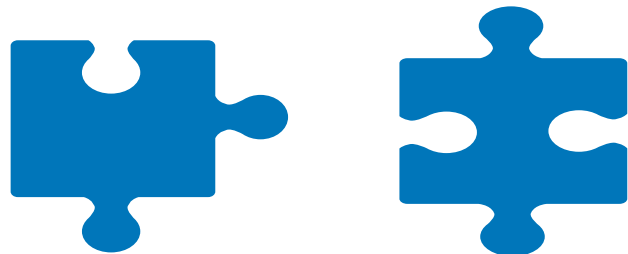


Innovative Technologien

für die Forschung

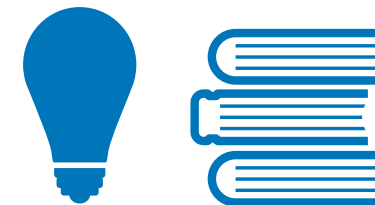


Zusammenarbeit



Bildung und Wissensvermittlung

u.a. die Aus- und Weiterbildung von Wissenschaftler(inne)n und Ingenieur(inne)n.
aber eben auch Bildungsprogramme für Alle



CERN Education Programme for Teachers and Students

Teacher Programmes

1 staff
1 fellow
1 doct



Science Gateway

1 staff
3 fellow
2 doct
1 technician



Competitions

1½ fellows
1 user



Internships

½ fellow



Publications

1 staff
1 admi
1 tech



Collaboration 1 user



Physics Education Research

2 doct



Education Team 2023 ... just now

Teacher Programme Participants 1998-2022 (Total: 13 871)



Member States 11 056

Austria 300 – Belgium 149 – Bulgaria 821
Czech Republic 171 – Denmark 348 – Finland 550
France 465 – Germany 1142 – Greece 952
Hungary 561 – Israel 56 – Italy 1139
Netherlands 227 – Norway 158 – Poland 588
Portugal 495 – Romania 20 – Serbia 84
Slovakia 307 – Spain 705 – Sweden 311
Switzerland 135 – United Kingdom 1372

Associate Member States in the pre-stage to Membership 165

Cyprus 16 – Estonia 105 – Slovenia 44

Associate Member States 889

Croatia 114 – India 15 – Latvia 76 – Lithuania 64
Pakistan 9 – Türkiye 403 – Ukraine 208

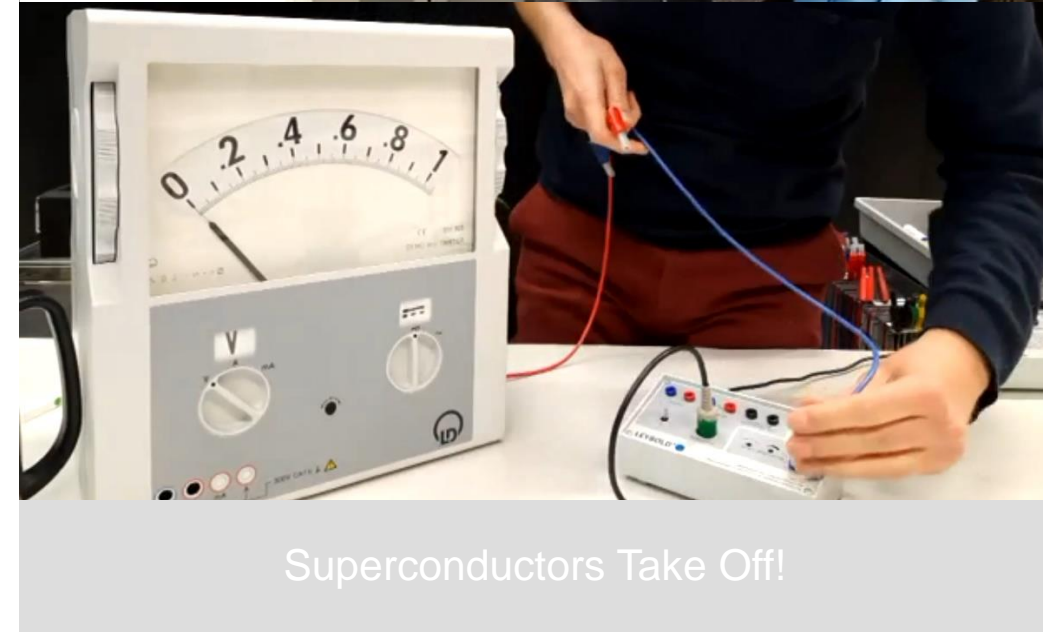
Observers 579

Japan 12 – Russia (suspended) 431
United States of America 136

Non-Member States and Territories 1182

Algeria 11 – Angola 11 – Argentina 3 – Armenia 3 – Australia 14 – Azerbaijan 2 – Bahrain 3 – Bangladesh 1 – Belarus 11
Bosnia & Herzegovina 36 – Brazil 273 – Burundi 2 – Cameroon 11 – Canada 20 – Cape Verde 5 – Chile 4 – Colombia 8
Costa Rica 4 – Dominican Republic 73 – Ecuador 2 – Egypt 3 – Eswatini 1 – Georgia 194 – Ghana 7 – Guinea Bissau 2
Indonesia 3 – Iran 15 – Ireland 10 – Jordan 13 – Kazakhstan 14 – Kenya 4 – Kuwait 1 – Kyrgyzstan 1 – Lebanon 21
Madagascar 2 – Malaysia 3 – Malta 51 – Mexico 113 – Moldova 4 – Mongolia 1 – Montenegro 17 – Morocco 2
Mozambique 24 – Nepal 6 – New Zealand 5 – Nigeria 2 – North Macedonia 13 – Palestinian Territories 5
People's Republic of China 3 – Philippines 2 – Qatar 1 – Republic of Korea 49 – Rwanda 20 – Sao Tome 8
Saudi Arabia 1 – Singapore 2 – South Africa 9 – Sri Lanka 3 – Taiwan 1 – Tajikistan 1 – Tanzania 1 – Thailand 23
Timor-Leste 10 – Uganda 3 – United Arab Emirates 1 – Uruguay 3 – Venezuela 1 – Vietnam 2 – Zimbabwe 1

It's Just a Phase!



Superconductors Take Off!

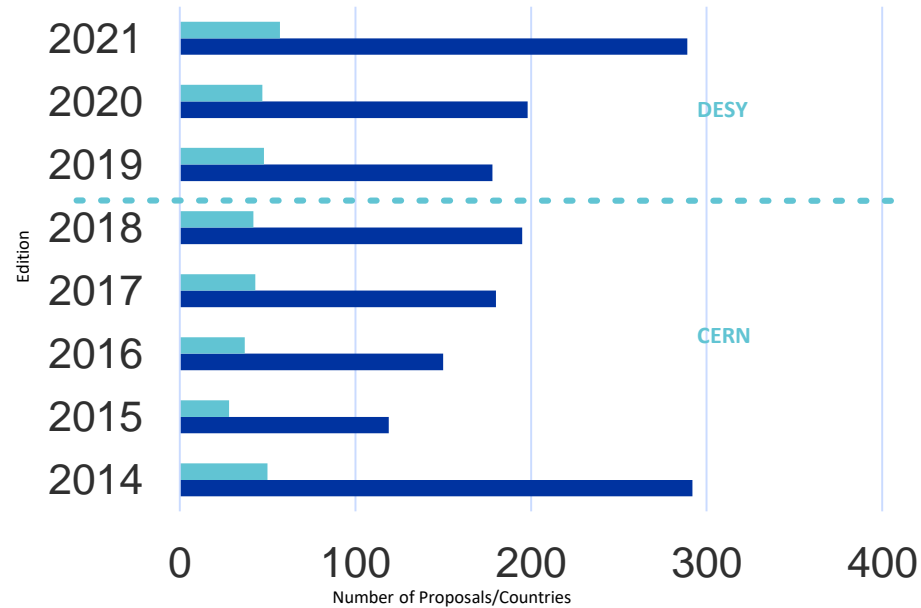
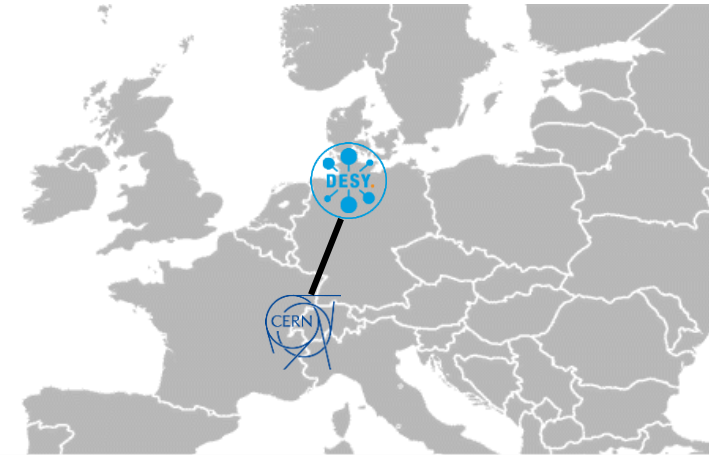
- Live interactive demonstrations of scientific phenomena
- Links to CERN research
- Questions and answers
- Various languages



Virtual Science Shows – the pandemic as great opportunity



- Competition for High-School Student Teams
- Normally at CERN's PS, 2019-21 at DESY
- Participation 2021
 - 298 proposals
- 2022
 - back at CERN for the finals of the competition
 - with 1 additional winning team at DESY



Beamline for Schools Competition

Fostering i

Sarah Zöchling

Link to CERN

Development of
interest in partic
students' interes
contexts to ...

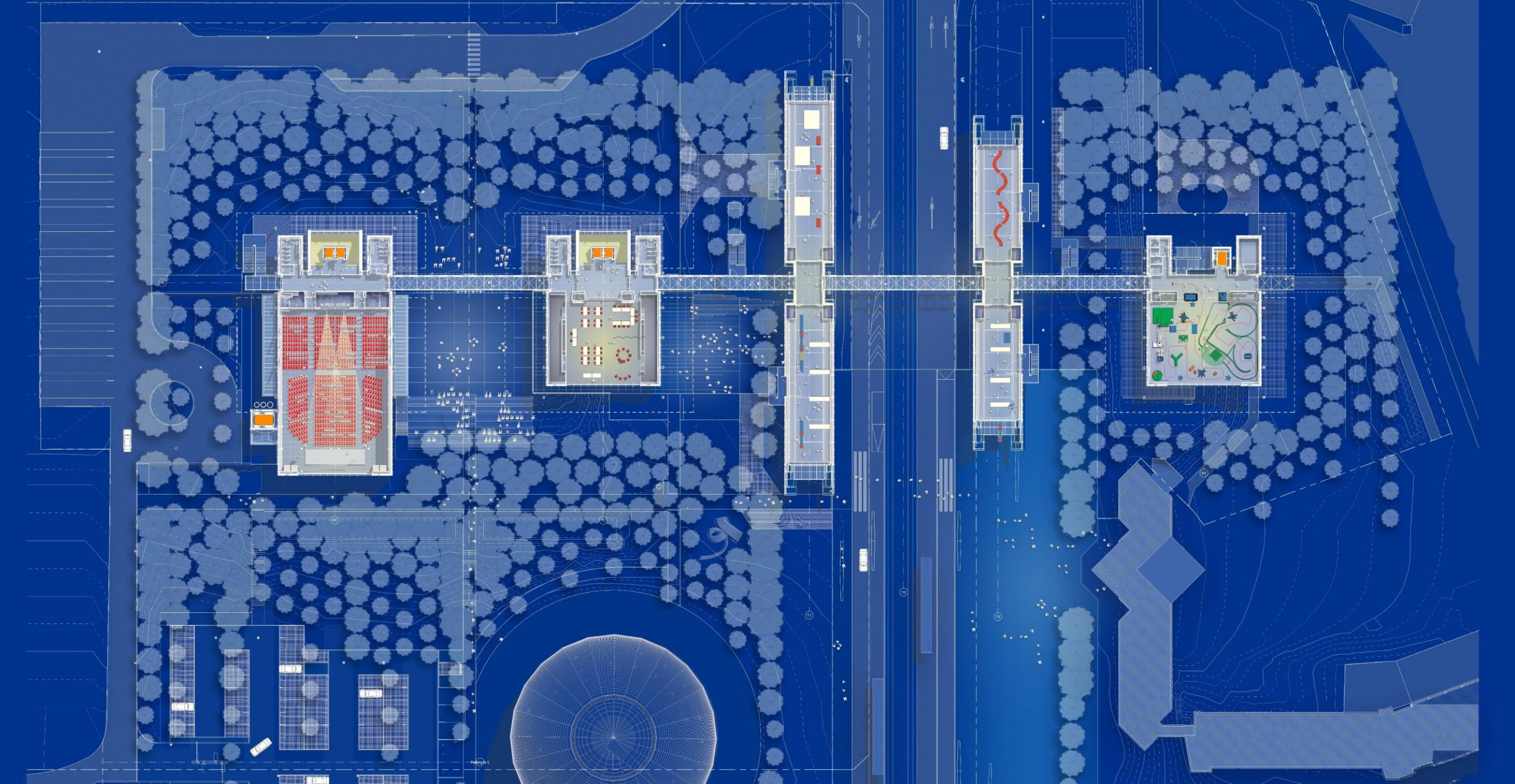
- define interest
- give recommen
material

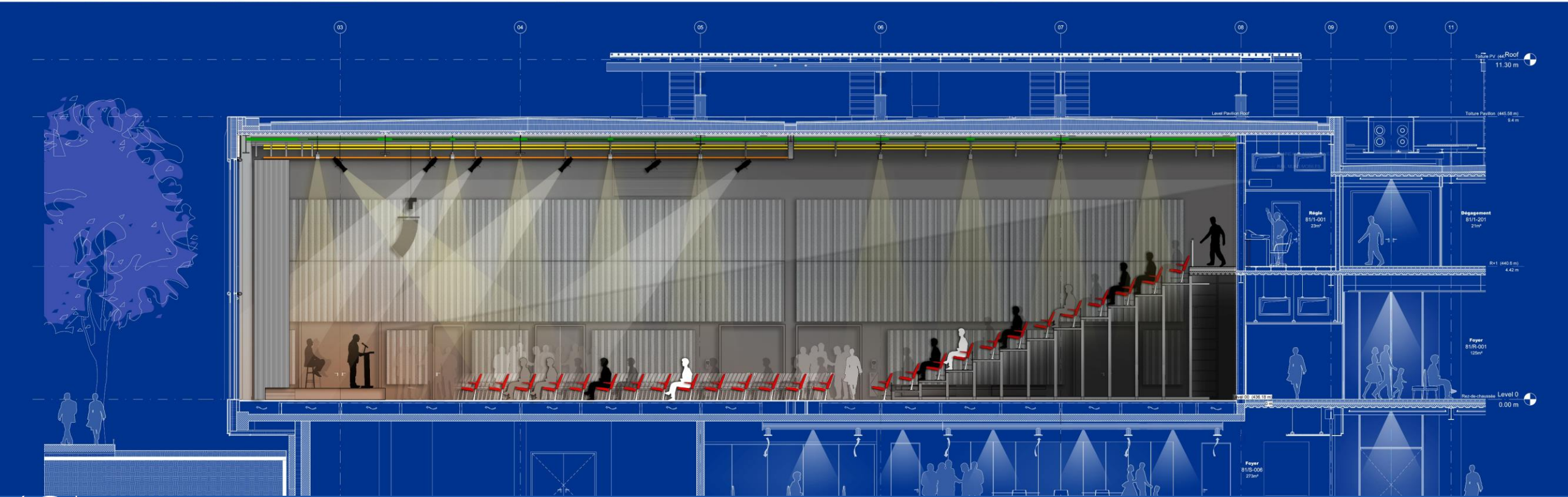
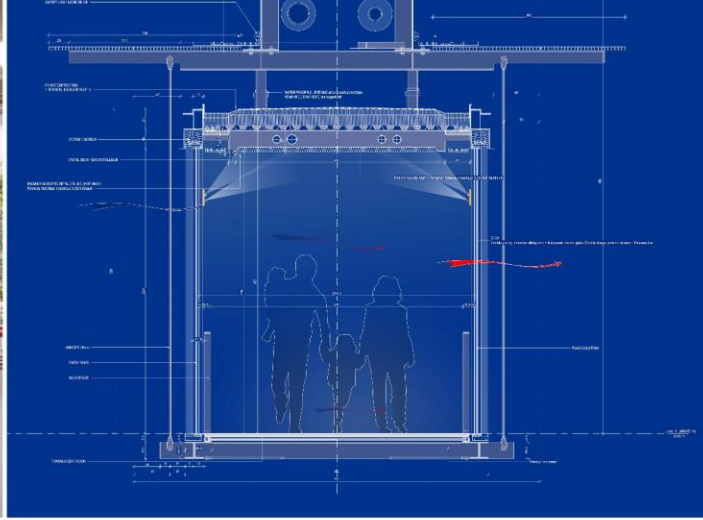




CERN Science Gateway







Ziel erreicht!

