

Grundlagenforschung in einer internationalen Perspektive

CERN – European Organization for Nuclear Research
The Organization, current research, and education.

Dr. Sascha Marc Schmeling

Science for peace

CERN was founded in 1954 with 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 – Turkey – 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 1200 MCHF (equivalent
to a medium-sized European
university)

As of 31 December 2020
Employees:
2635 staff, **756** fellows

Associates:
11 399 users, **1687** others

A laboratory for people around the world

Distribution of all CERN Users by the country of their home institutes as of 31 December 2020



Geographical & cultural diversity
Users of 110 nationalities
~ 23% women



Member States 6632

Austria 82 – Belgium 122 – Bulgaria 37 – Czech Republic 221
Denmark 35 – Finland 79 – France 794 – Germany 1185
Greece 138 – Hungary 67 – Israel 63 – Italy 1388
Netherlands 166 – Norway 78 – Poland 272 – Portugal 80
Romania 99 – Serbia 35 – Slovakia 66 – Spain 325
Sweden 96 – Switzerland 329 – United Kingdom 875

Associate Member States 27 in the pre-stage to membership

Cyprus 11 – Slovenia 16

Associate Member States 390

Croatia 38 – India 151 – Lithuania 13 – Pakistan 35
Turkey 124 – Ukraine 29

Observers 3071

Japan 211 – Russia 1021 – United States of America 1839

Other countries 1279

Algeria 2 – Argentina 15 – Armenia 10 – Australia 23 – Azerbaijan 2 – Bahrain 2 – Belarus 26 – Brazil 108
Canada 196 – Chile 22 – Colombia 15 – Cuba 3 – Ecuador 4 – Egypt 14 – Estonia 26 – Georgia 35
Hong Kong 20 – Iceland 3 – Indonesia 7 – Iran 13 – Ireland 6 – Kuwait 2 – Latvia 6 – Lebanon 17
Malaysia 4 – Malta 3 – Mexico 49 – Montenegro 5 – Morocco 18 – New Zealand 11 – Oman 1
People's Republic of China 334 – Peru 2 – Puerto Rico 2 – Republic of Korea 132 – Singapore 3
South Africa 57 – Sri Lanka 8 – Taiwan 50 – Thailand 16 – United Arab Emirates 2

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: U. Doselli



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

Scientific Policy Committee

Chairperson: L. Rivkin



- 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: FC Chair

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 



„Die Mission“

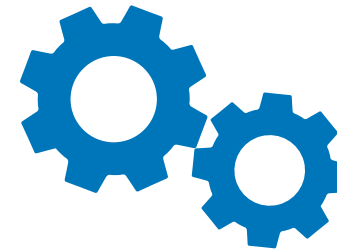
Grundlagenforschung

an der Grenze des menschlichen Wissens

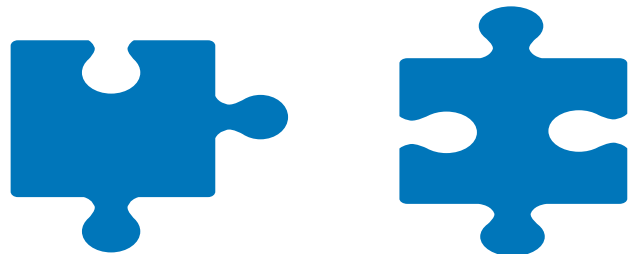


Innovative Technologien

für die Forschung

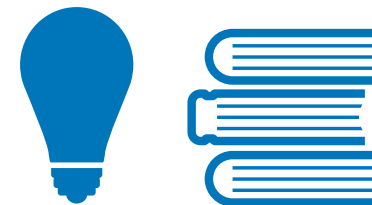


Zusammenarbeit

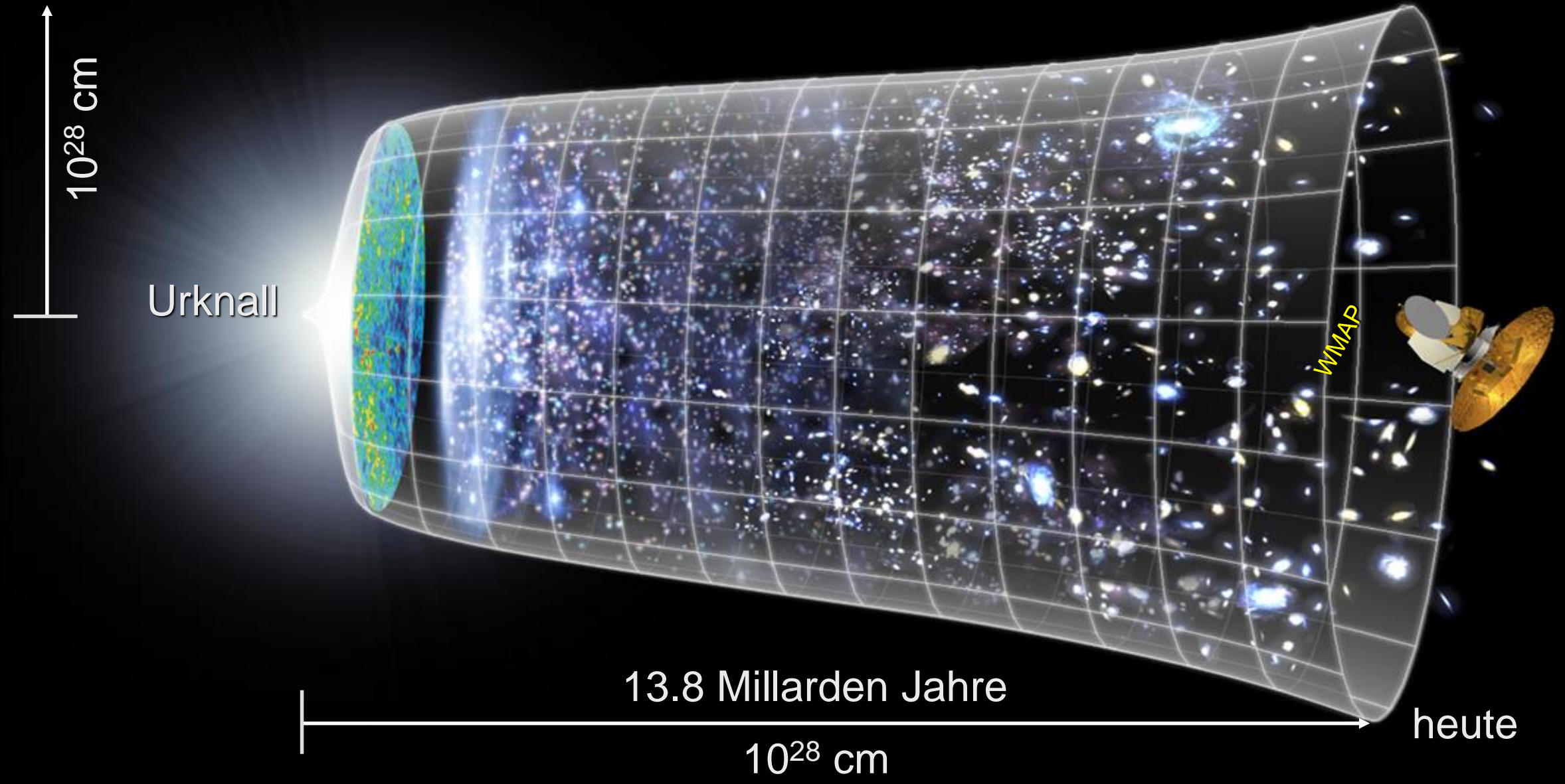


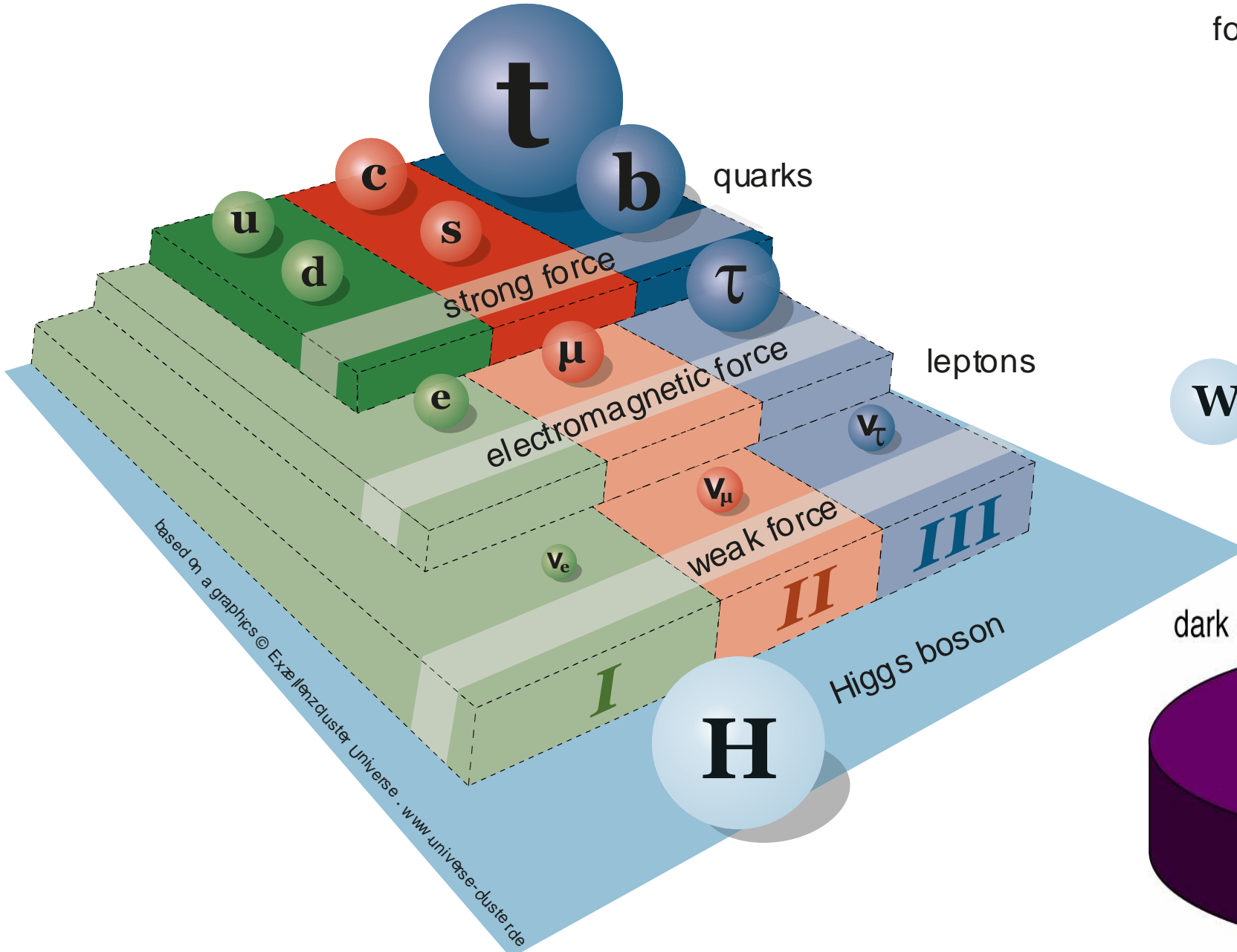
Bildung und Wissensvermittlung

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

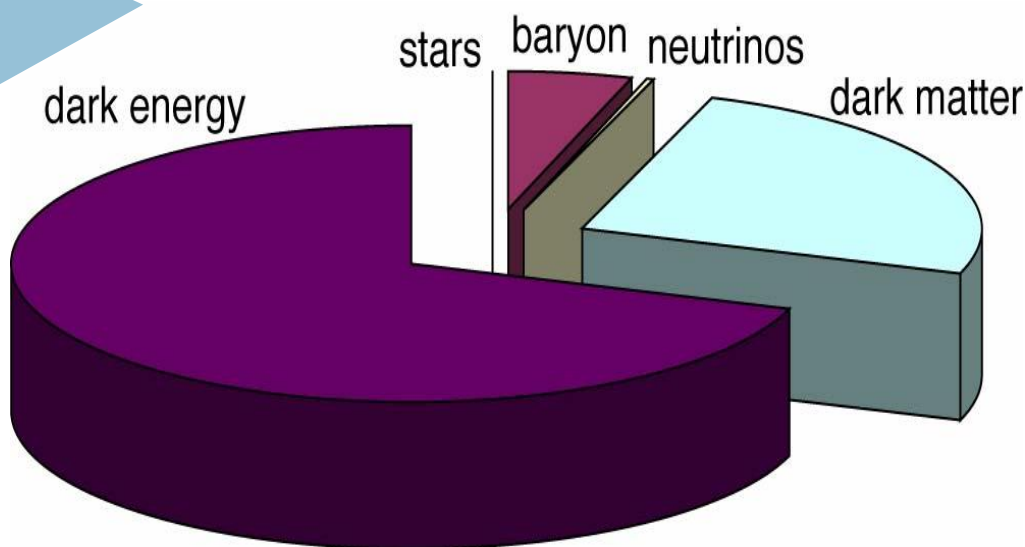
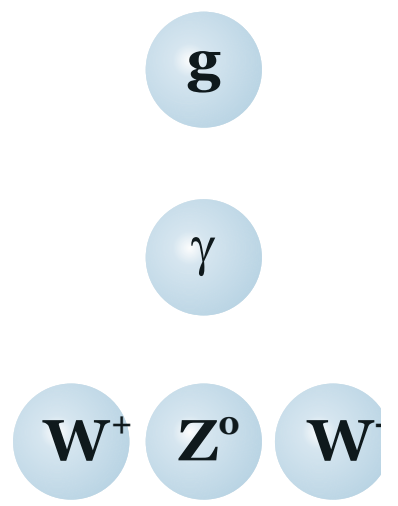


Die Wissenschaftliche Herausforderung Forschung über die Geschichte des Universums





force carriers



LHCb: Flavour Anomalies

Intriguing results from LHCb in bottom and charm decays, for example in $b \rightarrow s \ell \ell$ decays

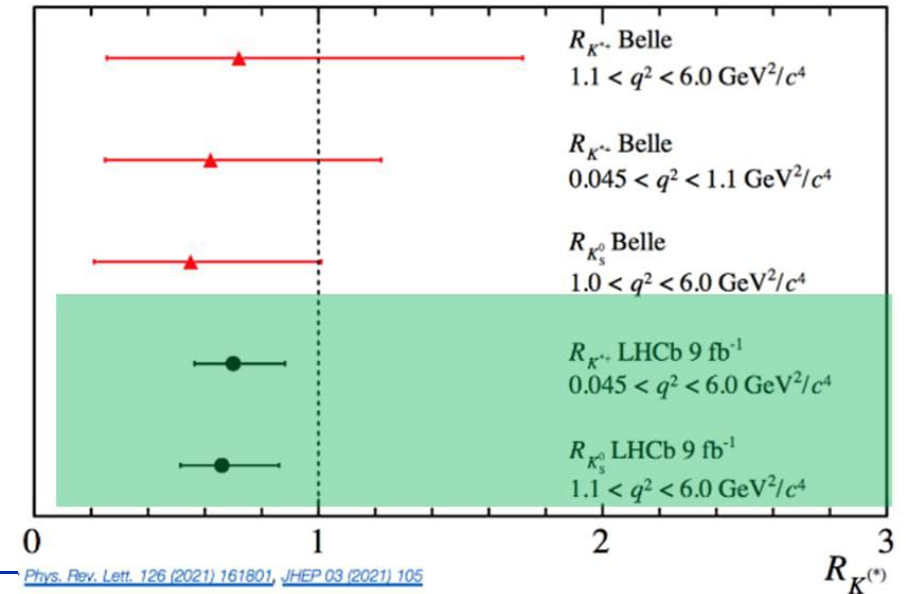
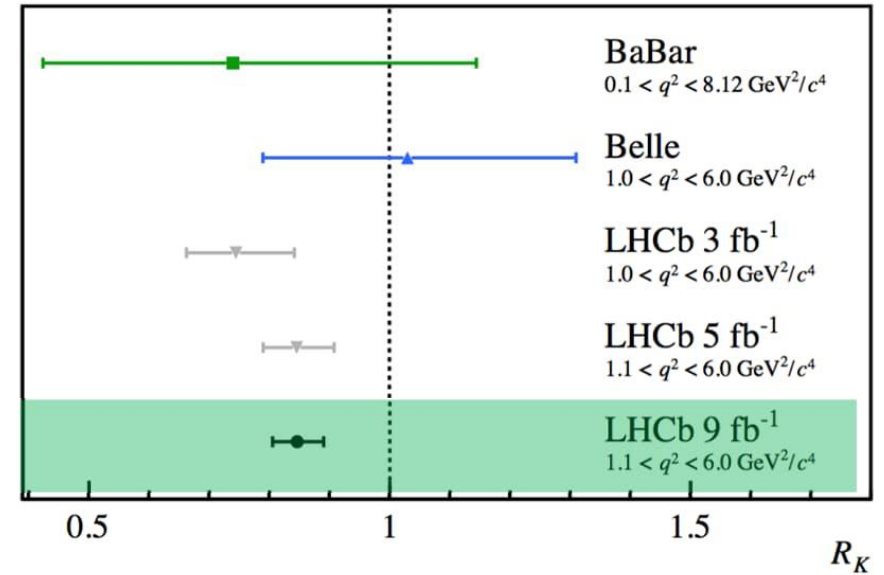
Recall: SM predicts equal couplings of electrons and muons

- March 2021: 3.1 sigma muon deficit in $B \rightarrow K \ell^+ \ell^-$
- October 2021: ≈ 1 sigma muon deficits in $B \rightarrow K^{*+} \ell^+ \ell^-$ and $B \rightarrow K_s^0 \ell^+ \ell^-$

Flavour anomalies workshop October 20th: combined LHC experiments event incl. theory

Eagerly waiting for more results from the LHC experiments to clarify the origin of these anomalies

$$R_K = N(B \rightarrow K \mu^+ \mu^-) / N(B \rightarrow K e^+ e^-)$$



[Phys. Rev. Lett. 126 \(2021\) 161801](#), [JHEP 03 \(2021\) 105](#)

CMS: Measurement of Higgs Total Width

Evidence for off-shell Higgs production in

$H \rightarrow ZZ \rightarrow 2l2\nu$ and $4l$

Recall: $m_H = 125$ GeV, $m_Z = 91$ GeV

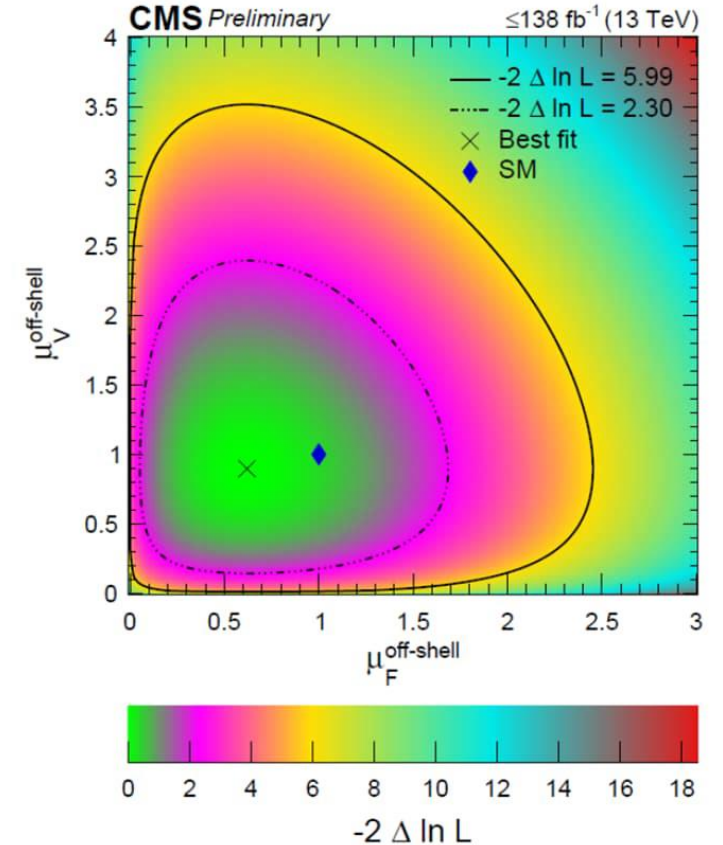
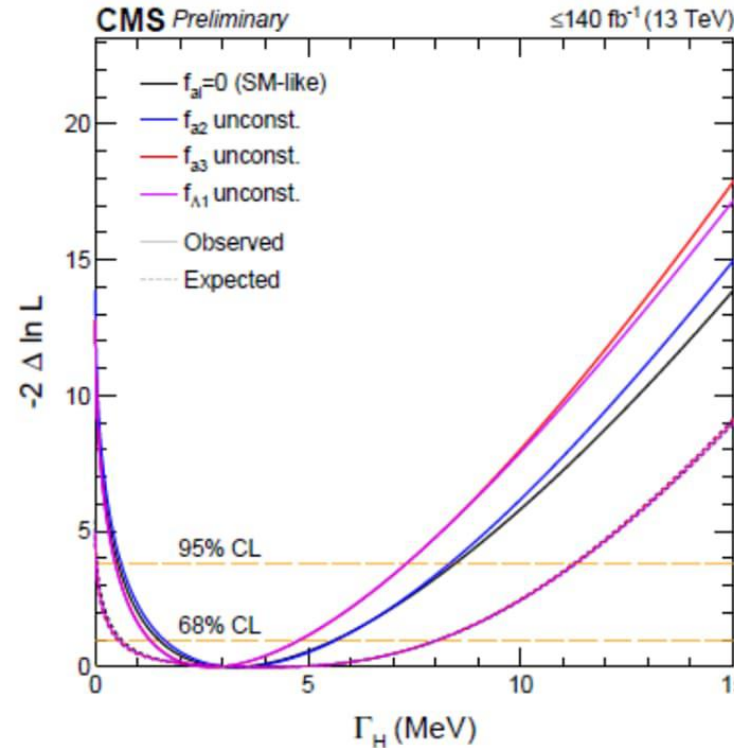
on-shell $H \rightarrow ZZ^*$

off-shell $H^* \rightarrow ZZ$ (approx. 10%)

- Allows measurement of the Higgs total width:

$$\Gamma_H = 3.2^{+2.4}_{-1.7} \text{ MeV}$$

- Compatible with SM expectation 4.1 MeV
- Width zero excluded with 3.6 sigma
- Provides also test of anomalous couplings



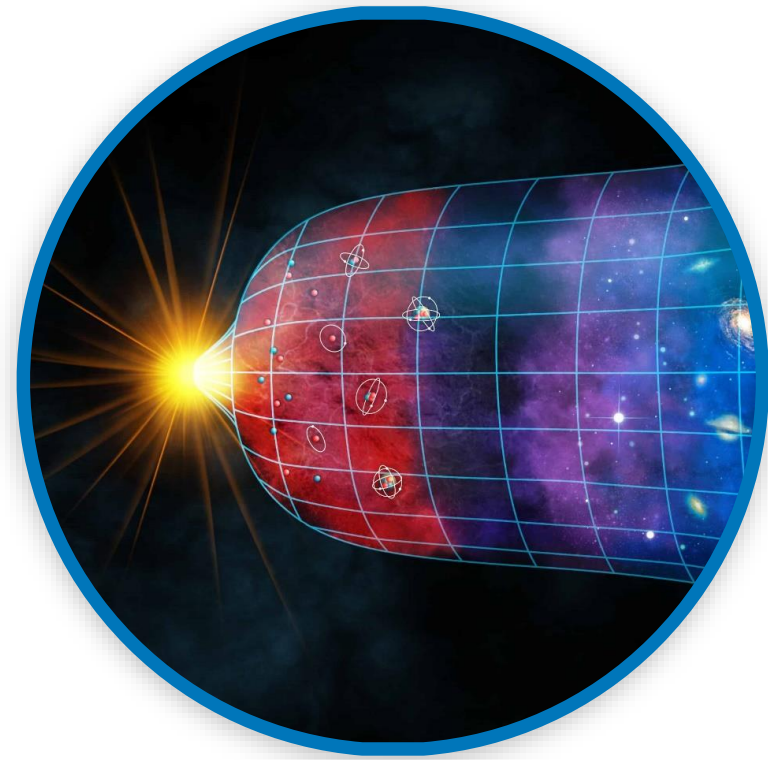
This is also a measurement of the lifetime of the Higgs boson: $\tau = 2 \cdot 10^{-22} \text{ s}$

weitere Forschungsfragen

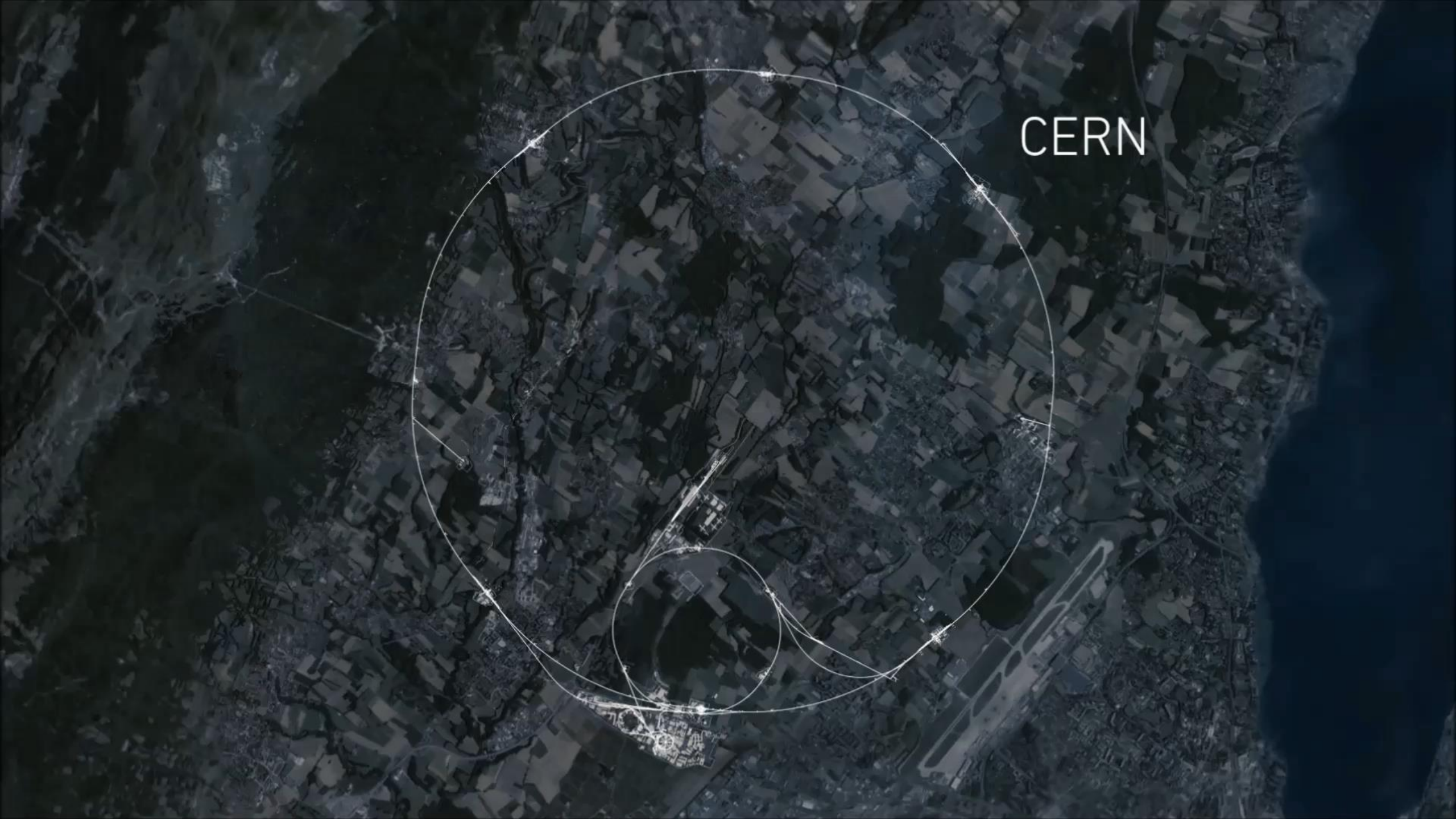
das frühe Universum

Antimaterie

Dunkle Materie



CERN



„Die Mission“

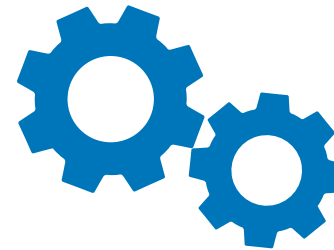
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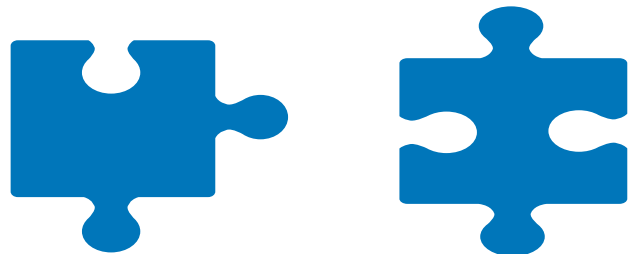


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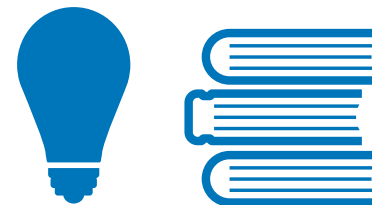


Zusammenarbeit



Bildung und Wissensvermittlung

u.a. die Aus- und Weiterbildung von Wissenschaftler(inne)n und Ingenieur(inne)n.
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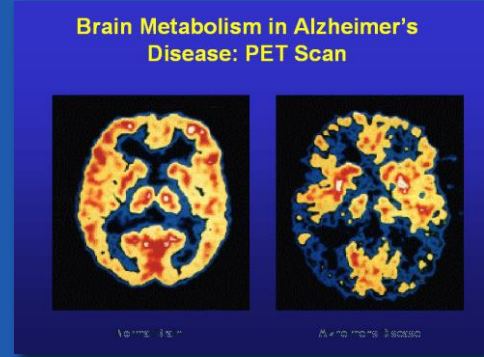
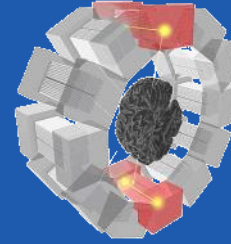
Particle Detection

Imaging

ClearPEM



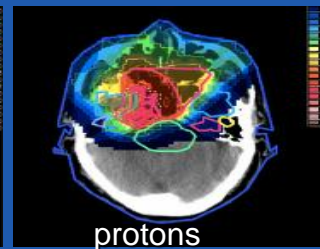
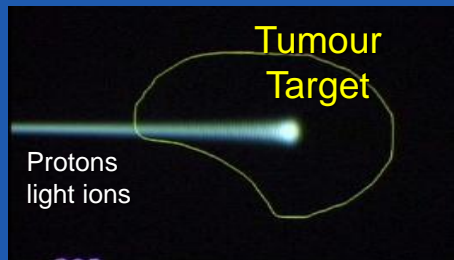
PET Scanner



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?

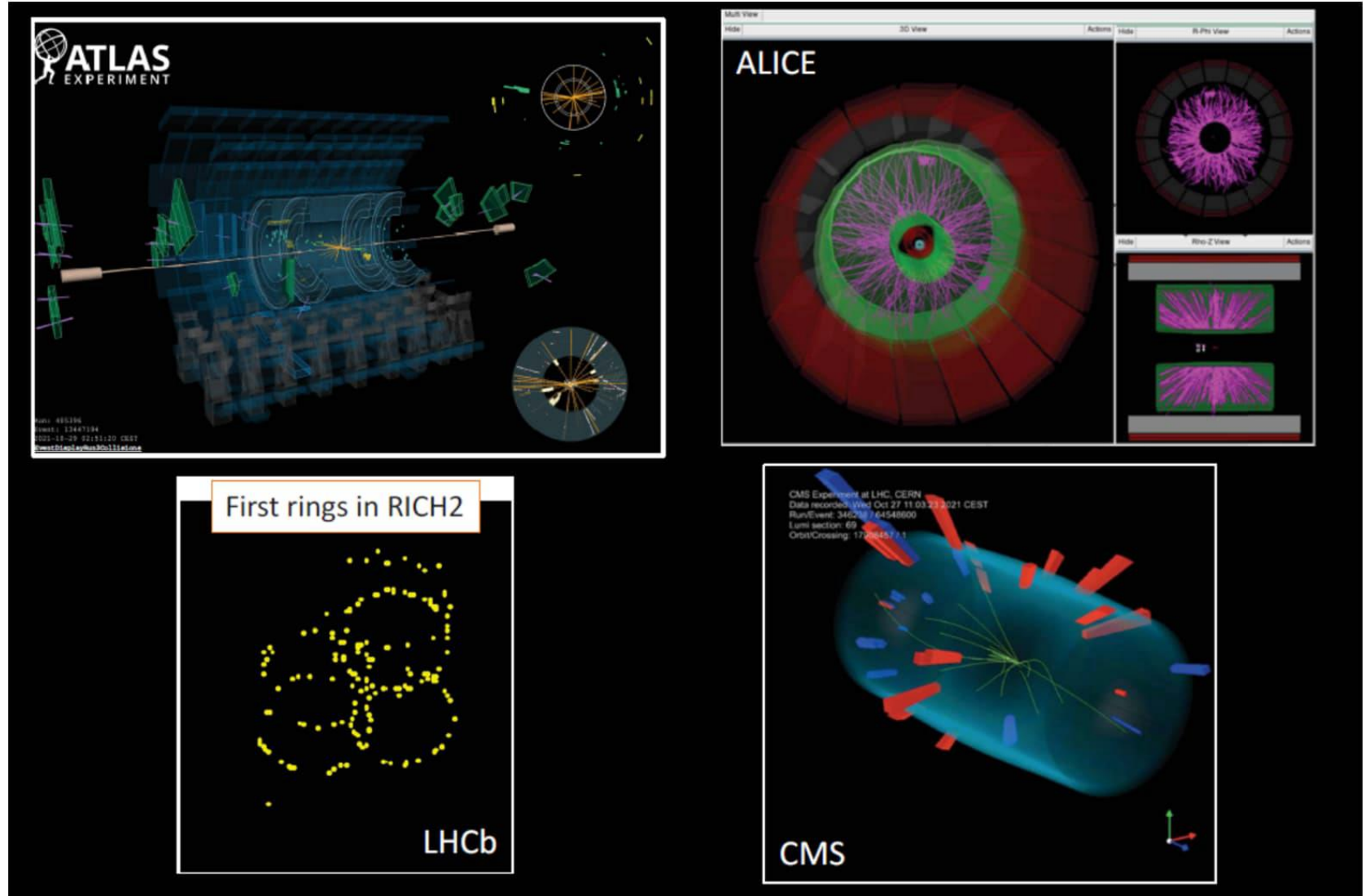
Pilot Run October 2021

All 4 experiments successfully participated and took collision data

Exceptional achievement under very difficult circumstances!

Good prospects to start Run 3 with upgraded detectors in spring 2022

However: Impact of Covid remains a big challenge!





ANTIMATTER FACTORY

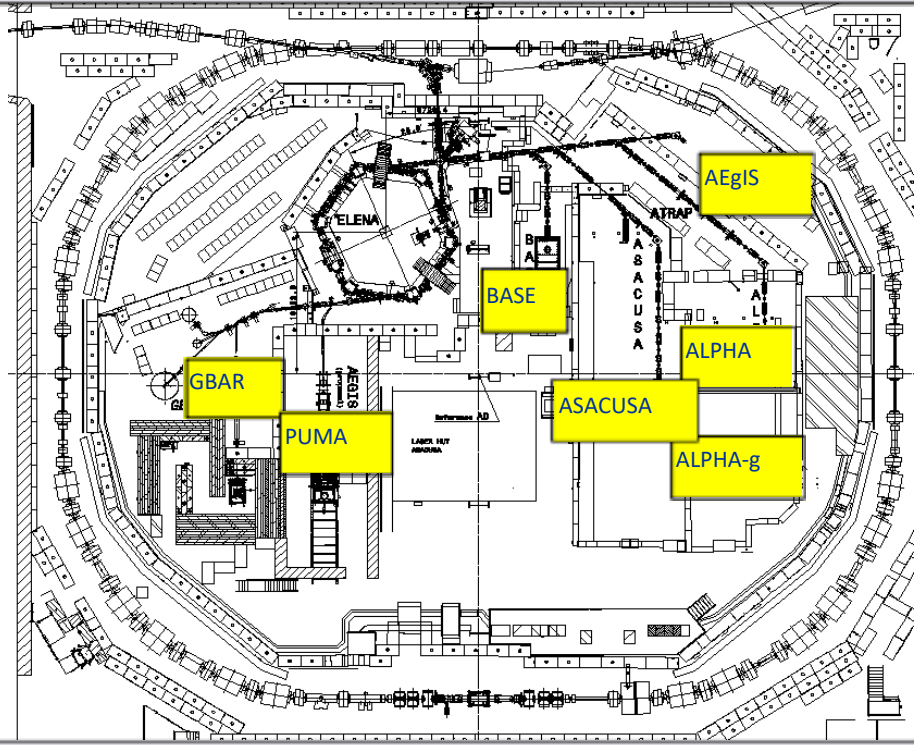
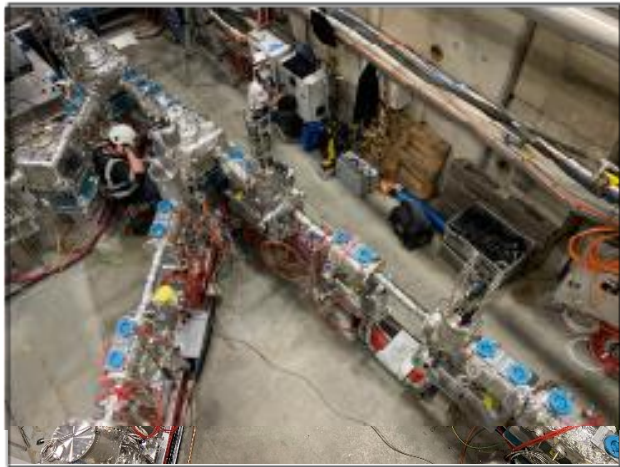
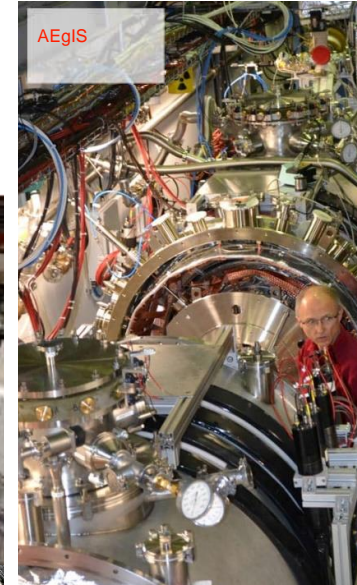
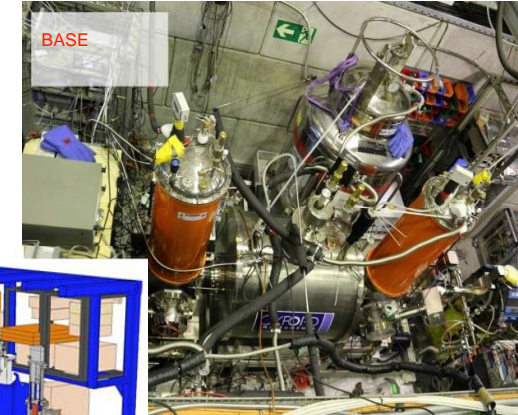
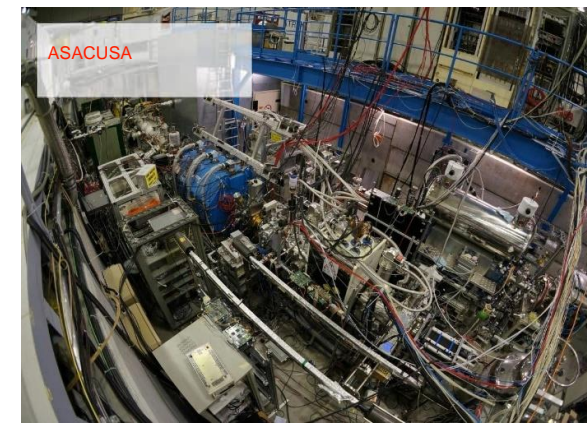


2021 highlights

Smooth AD restart after LS2

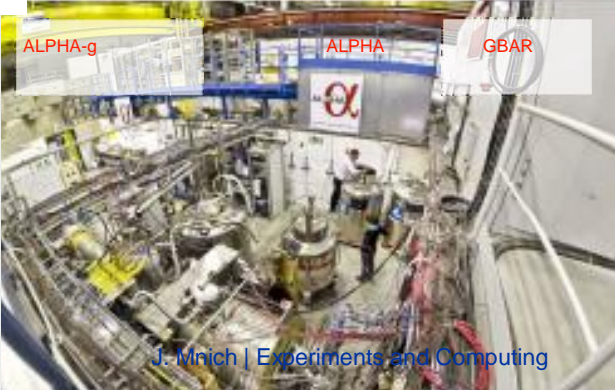
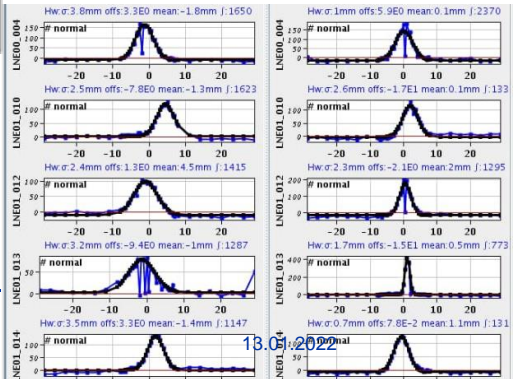
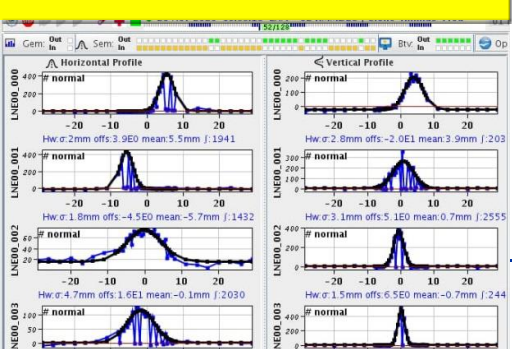
ELENA: new 100 keV TL's 1st operation

60 Research Institutes/Universities – 350 Scientists – 6 Active Collaborations



Excellent performance: stable beams, stable intensity, reliable!

Beam profiles in transfer lines (TL's)



13.01.2022

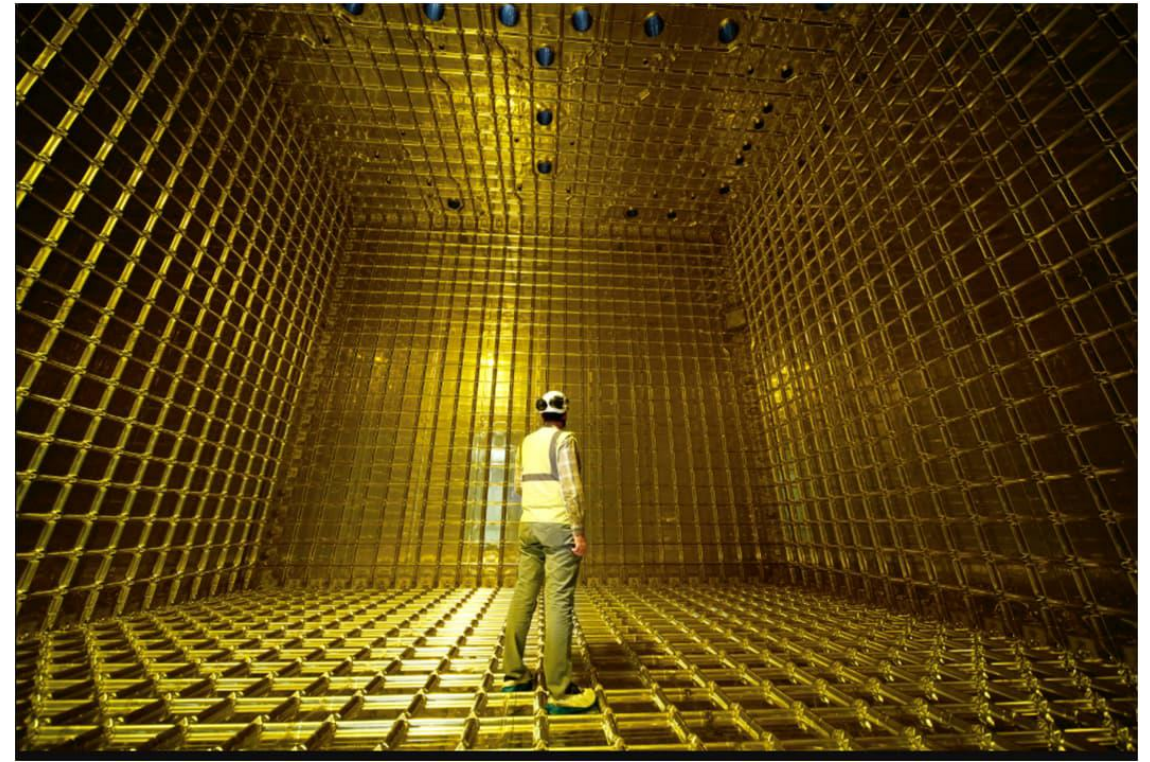
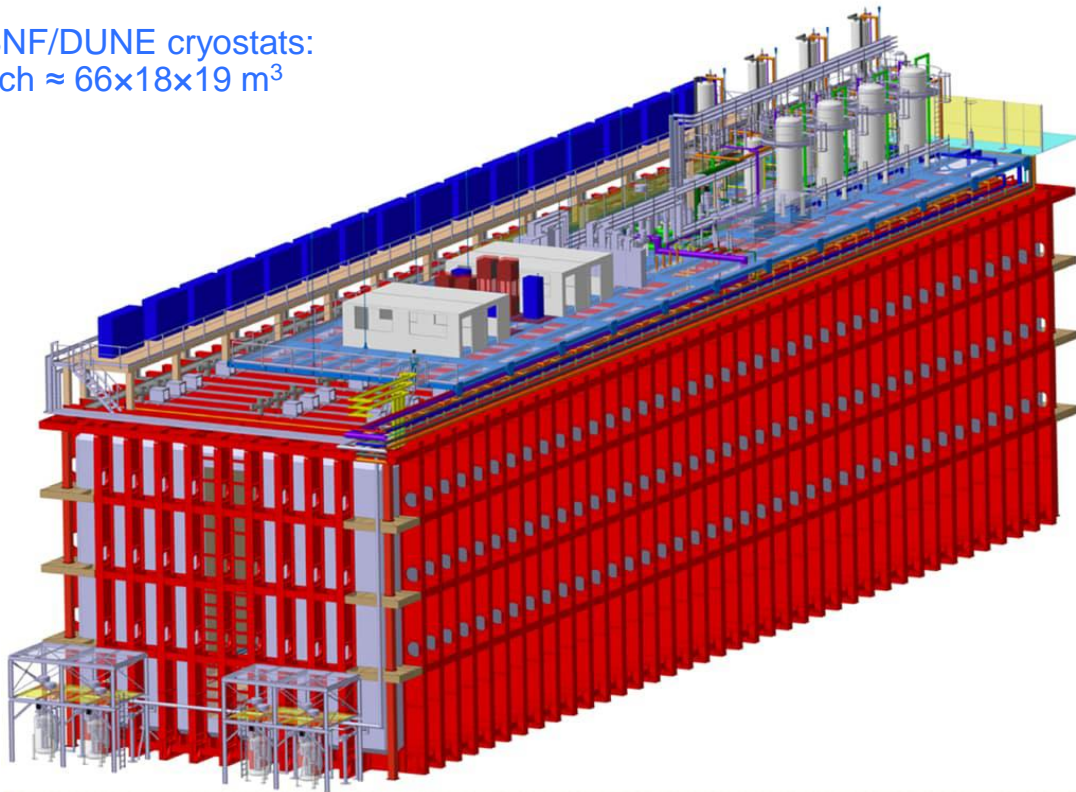
J. Munch | Experiments and Computing

CERN Neutrino Platform

Main activity:

- Procurement and construction of the large 2 cryostats for LBNF/DUNE will commence in 2022

LBNF/DUNE cryostats:
each $\approx 66 \times 18 \times 19 \text{ m}^3$



1:20 scale cryostat at the Neutrino Platform $\approx 12 \times 12 \times 12 \text{ m}^3$

In addition:

- Development of LAr TPC for DUNE (ProtoDUNE) in two 1:20 scale cryostats
- Several R&D projects also for T2K and HyperK

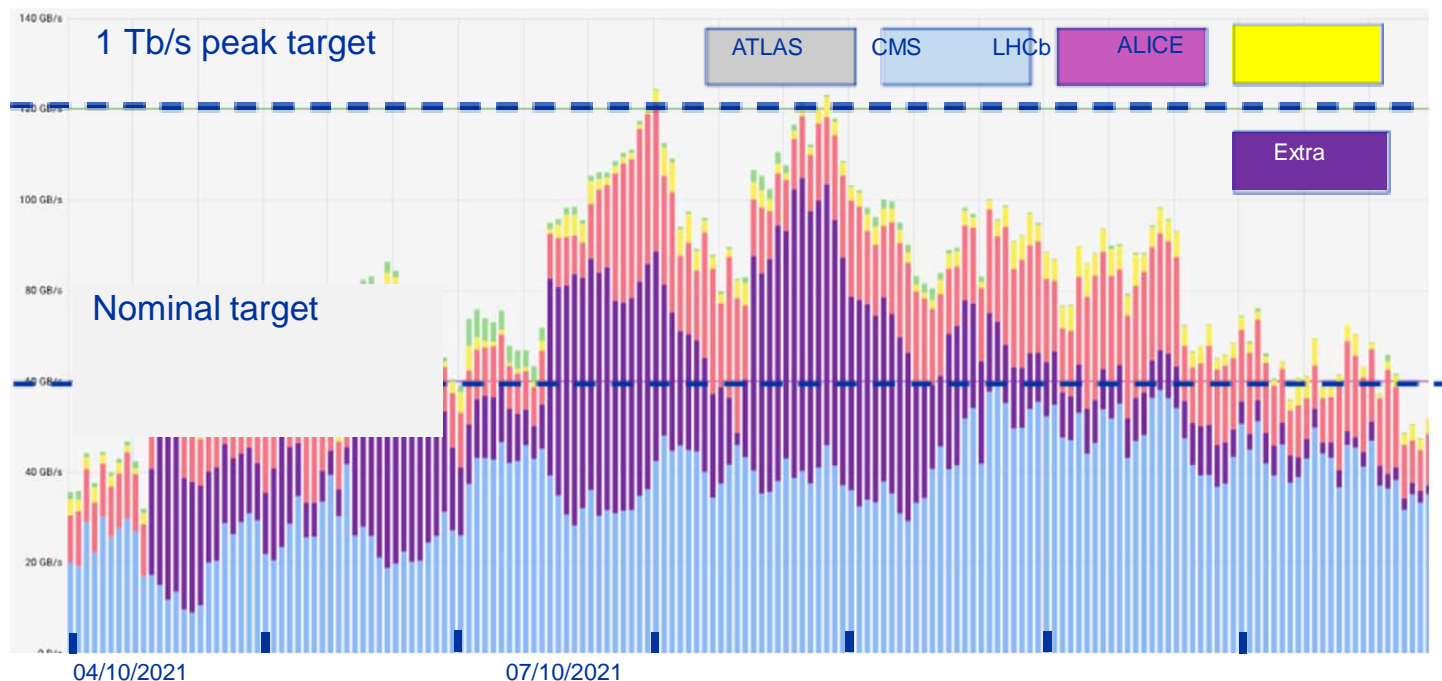
Status Computing: Commissioning for Run3

Planned data challenges executed

- Testing the network and archive storages

Targets were met

- Nominal rate sustained
- Peak transfer rate were reached



Data challenges are part of a longer-term process to prepare for the HL-LHC needs

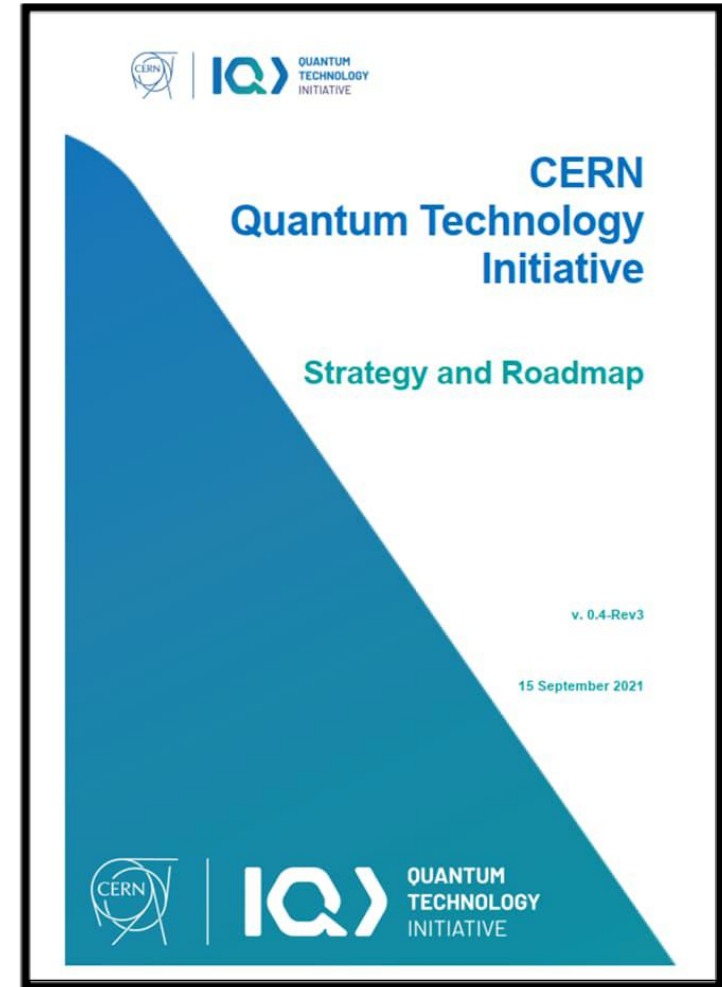
More commissioning tests are planned before the start of Run 3

CERN Quantum Technology Initiative

Established in September 2020

Achievements in 2021:

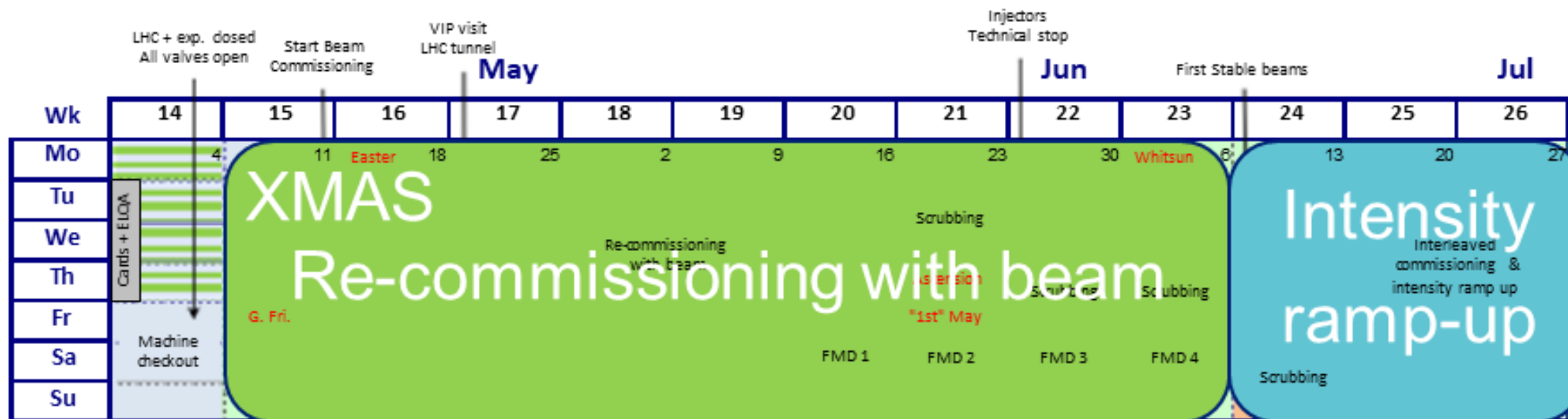
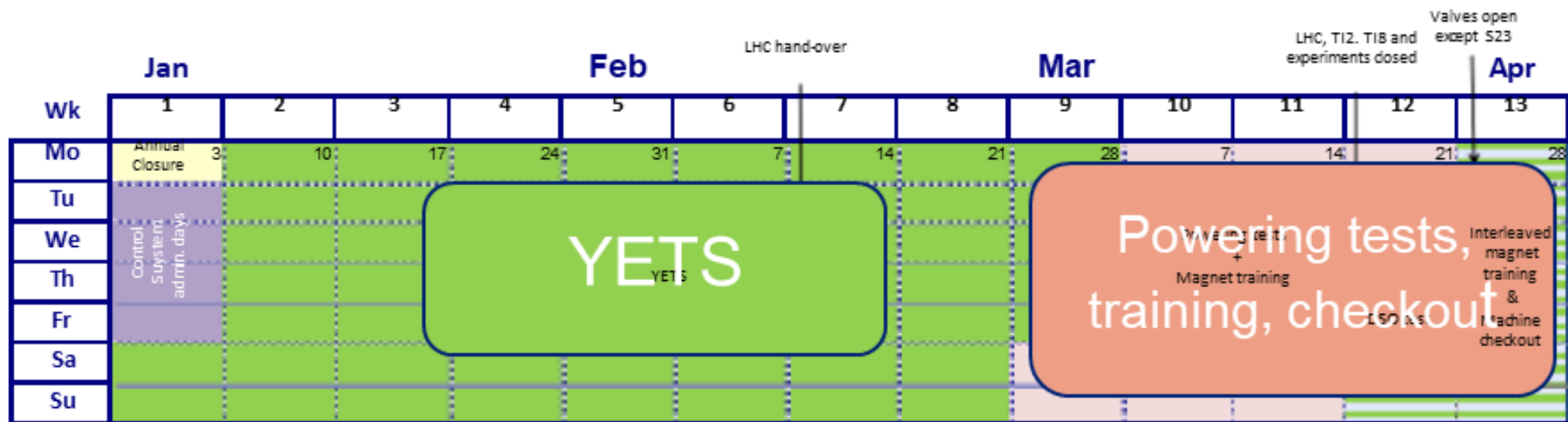
- **Setting up the initiative and its governance**
 - Coordination Task Force, Advisory Board, Web site, comms channels, branding, awareness
- **Projects and PhD programme**
 - Research programme as part of CERN DOCT programme
 - Research collaborations with institutes in the Member States and beyond (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



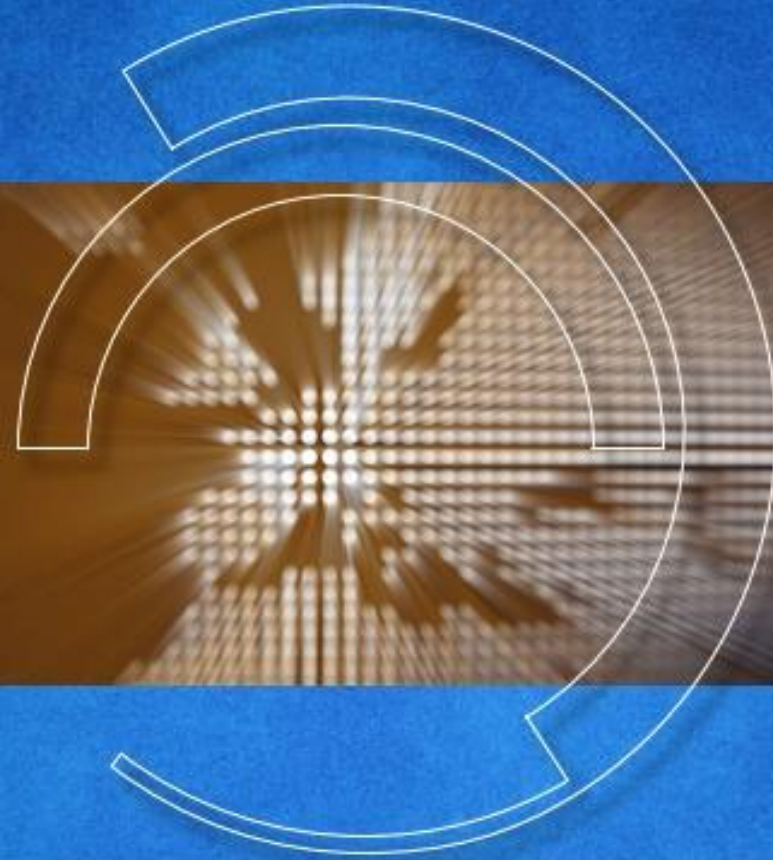
<https://doi.org/10.5281/zenodo.5553774>

LHC Schedule 2022

Approval by Research Board of 1 December 2021



Und dann?



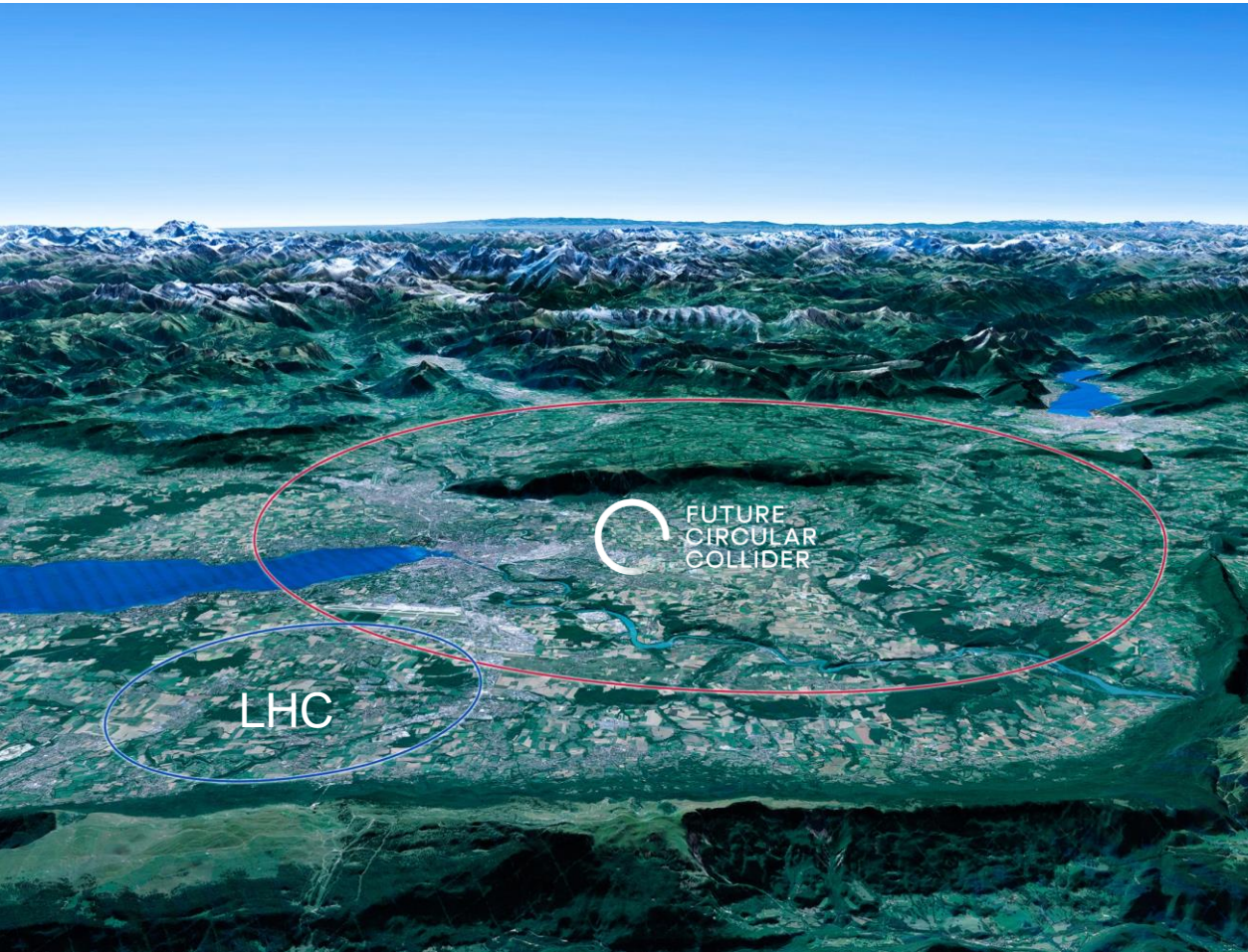
2020 UPDATE OF THE EUROPEAN STRATEGY
FOR PARTICLE PHYSICS

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:**

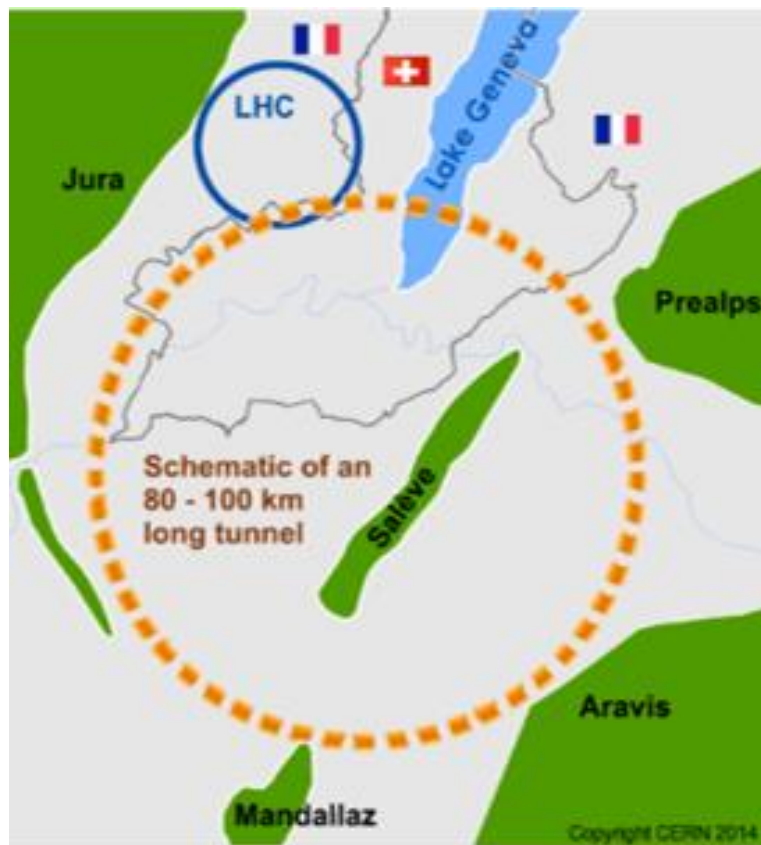
- Fully exploit the LHC & HL-LHC.
- Build a Higgs factory to further understand this unique particle.
- Investigate the technical and financial feasibility of a future energy-frontier 100 km collider at CERN.
- Ramp up relevant R&D.
- Continue supporting other projects around the world.



The FCC Integrated Programme

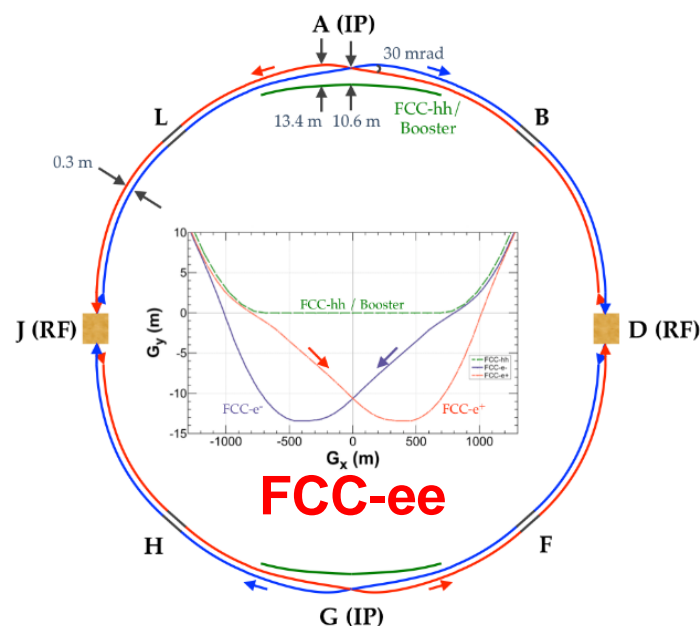
Inspired by successful LEP – LHC Programmes at CERN

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



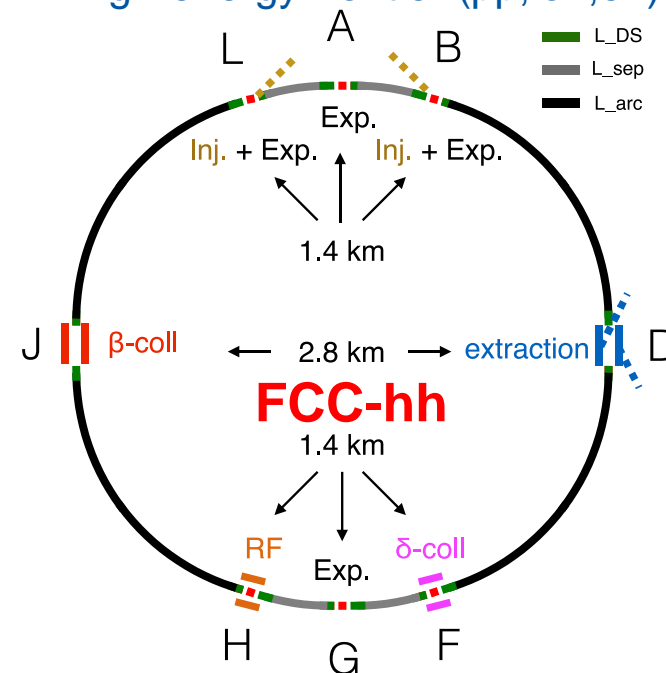
2020 - 2040

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



2040 - 2055

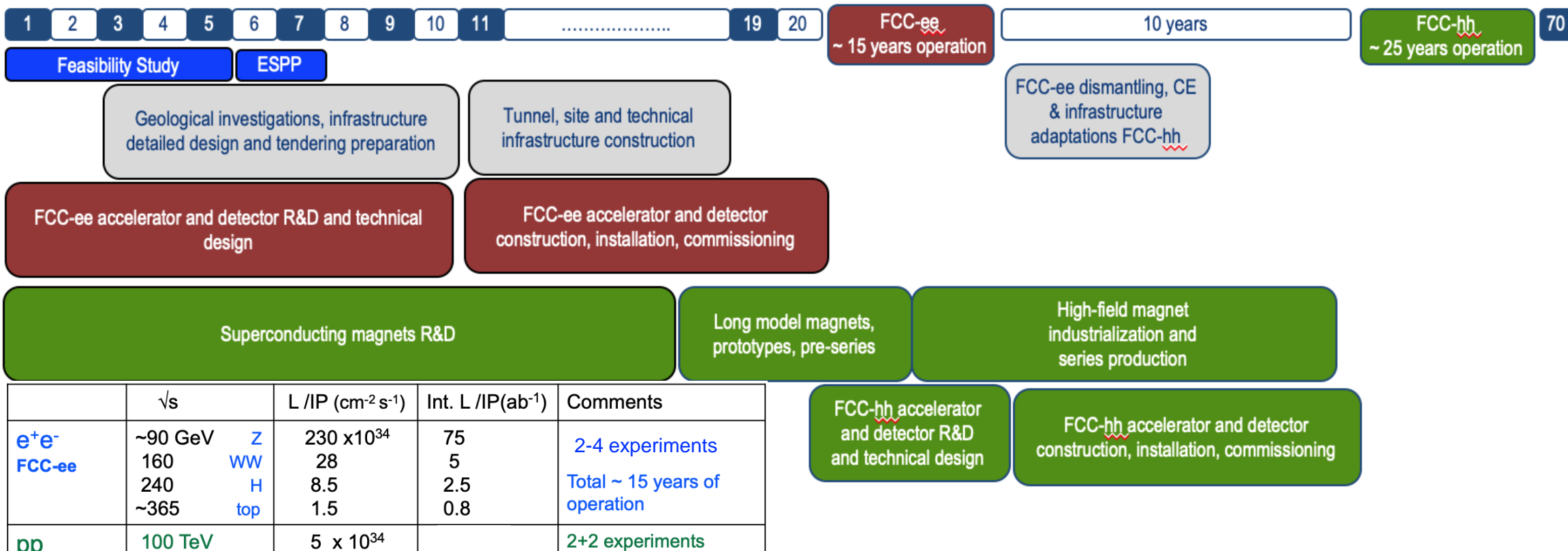
Phase 2 : FCC-hh
proton – proton Collider
High-energy frontier (pp, ion, eh)



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	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++

„Die Mission“

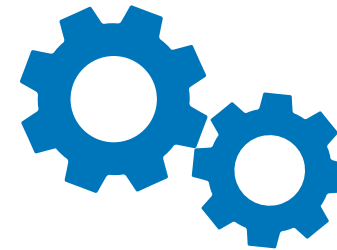
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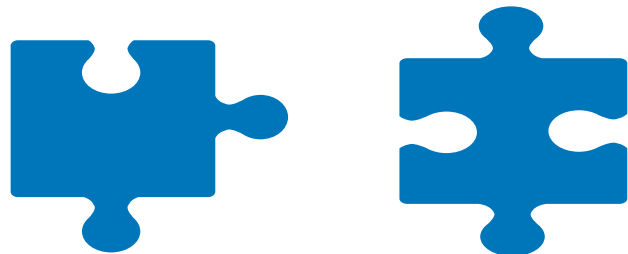


Innovative Technologien

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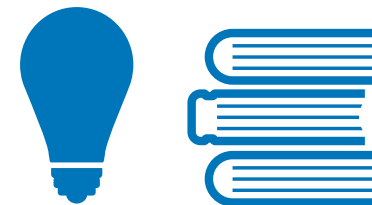


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CERN Education Programme for Teachers and Students

Teacher Programmes

1 staff
1 fellow



S'Cool LAB

1 fellow
2 doct
1 technician



Competitions

2 fellow
1 user



Internships

1 fellow



Publications

1 staff
1 admin
1 tech



Collaboration 1 user



Physics Education Research 3 doct



1 staff
3 fellows

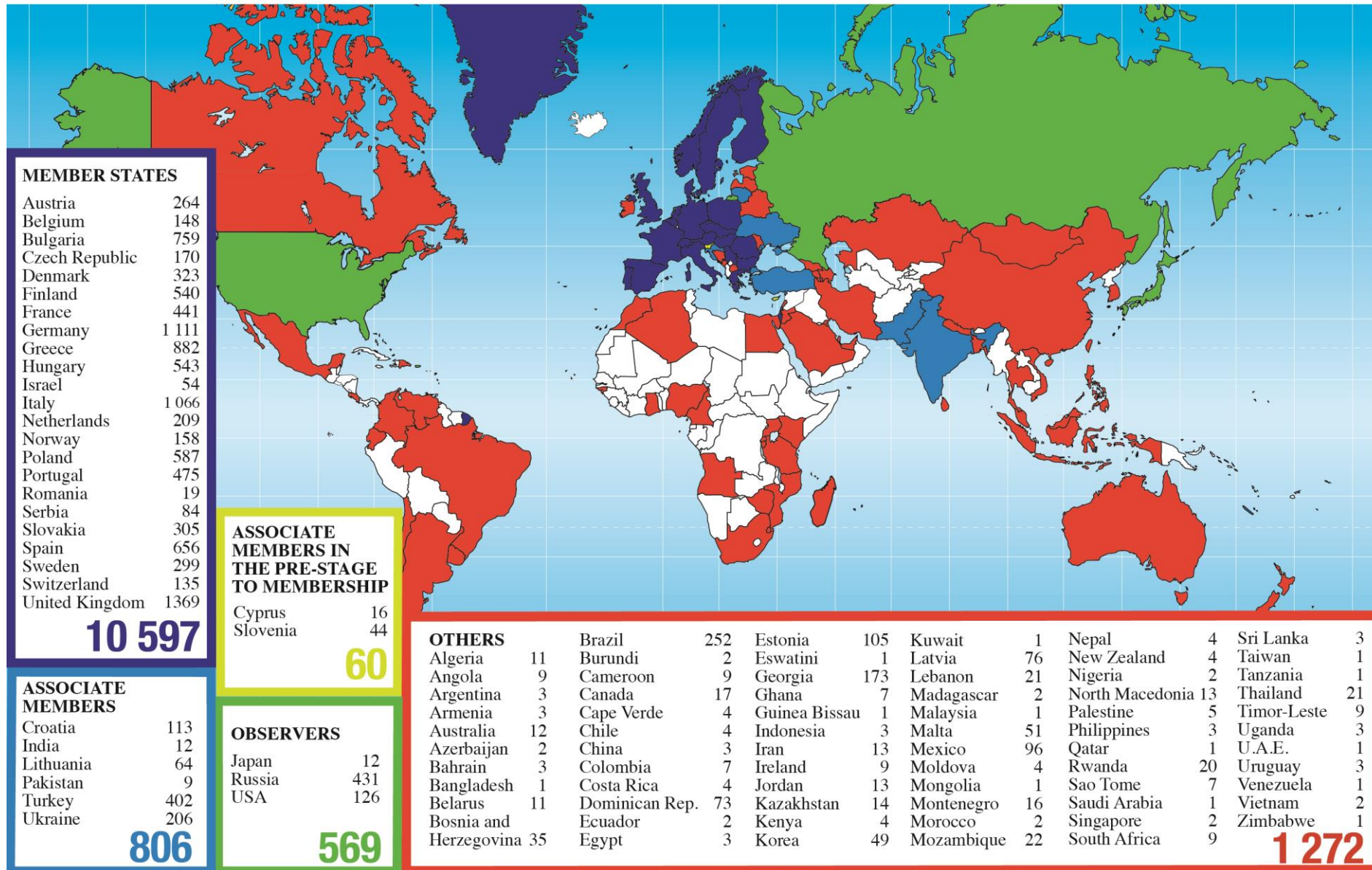


1 doct



Education Team 2022

Teacher Programme Participants 1998 - 2020 (Total: 13 304)



S'Cool
LAB

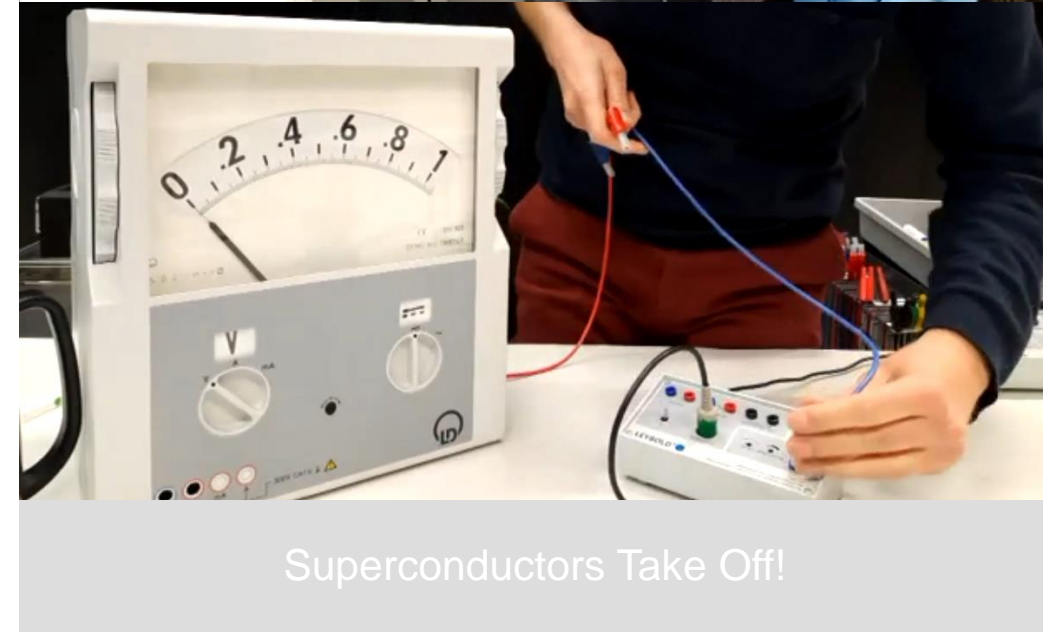
Welcome

There is always a way to do it
better... find it!

If you can't explain it simply,
you don't understand it well enough



It's Just a Phase!



Superconductors Take Off!

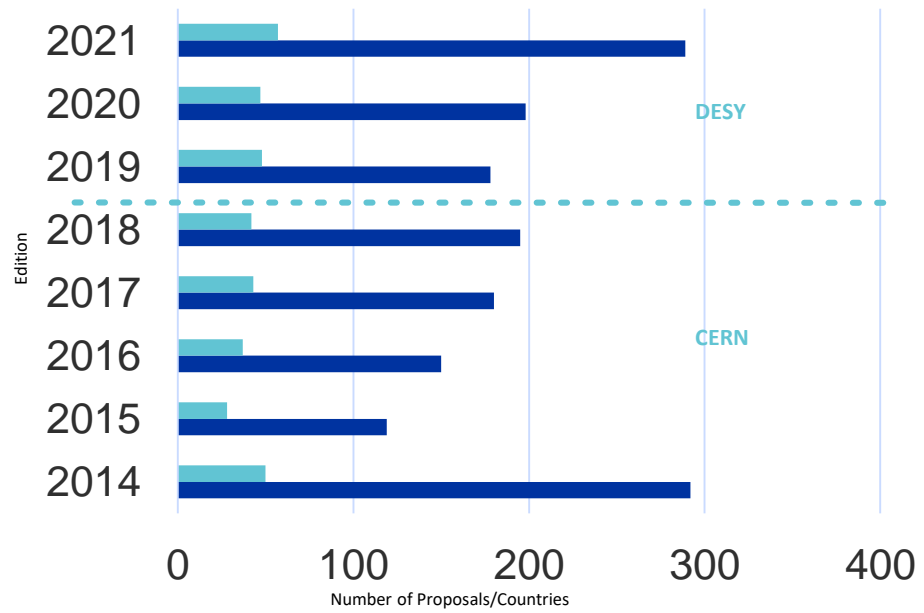
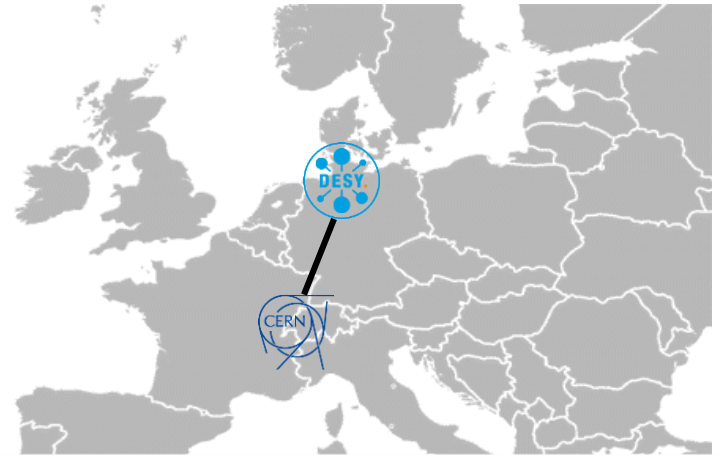
- Live interactive demonstrations of scientific phenomena
- Links to CERN research
- Questions and answers
- Various languages



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
- Italian Participation
 - winning teams in 2015, 2017, and 2021



Evaluation of CER

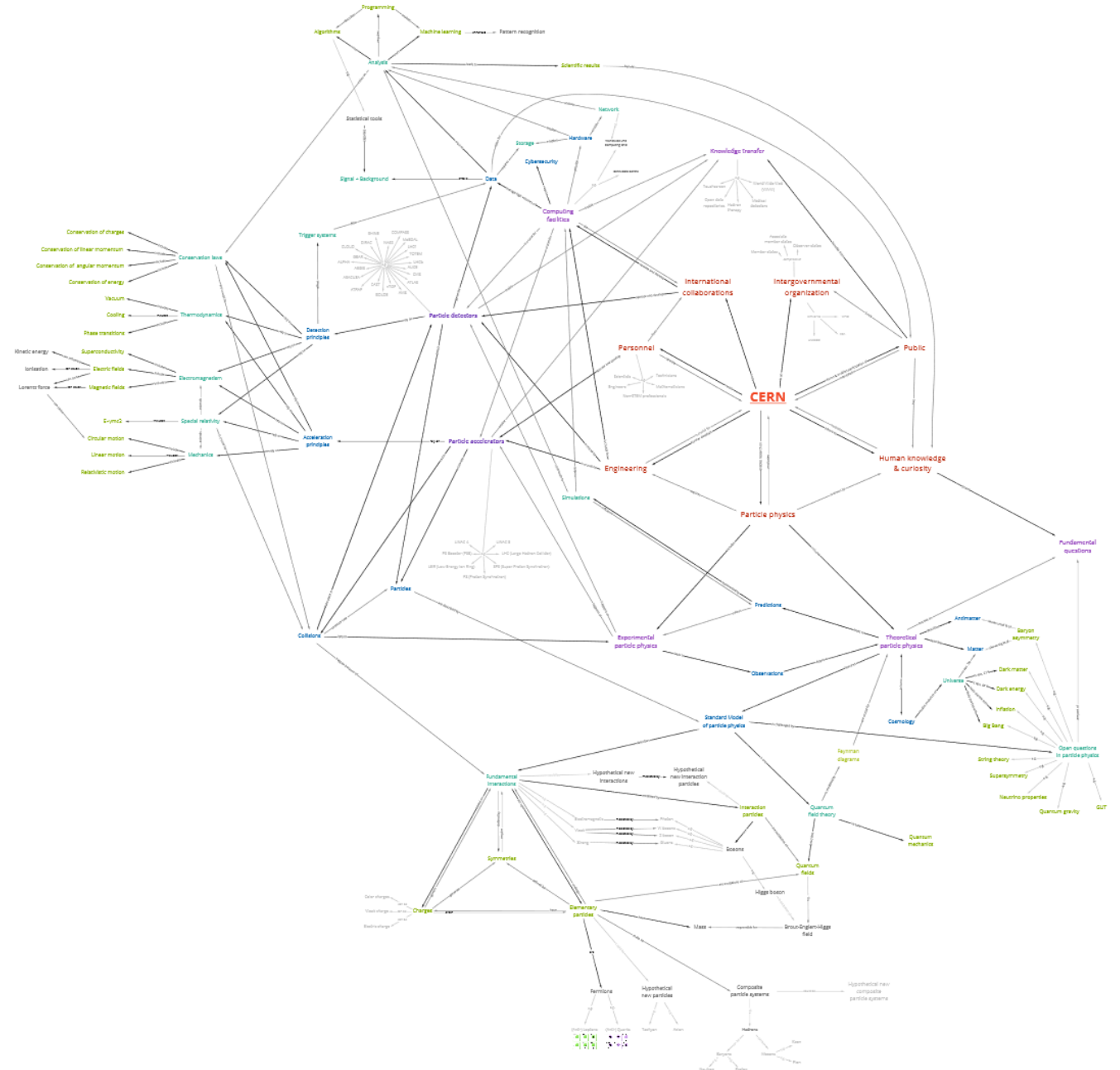
Anja Kranjc Horvat

[Link to CERN](#)

Evaluation of CERN’s Tea
overview of concepts in th
physics” to ...

- inform and improve C
- create a valuable tea

Paper: Kranjc Horvat, A., Wiener, J., S
Learning goals of professional devel
institutions: A Delphi study with differ
Teacher Education.



Fostering i

Sarah Zöchling

Link to CERN

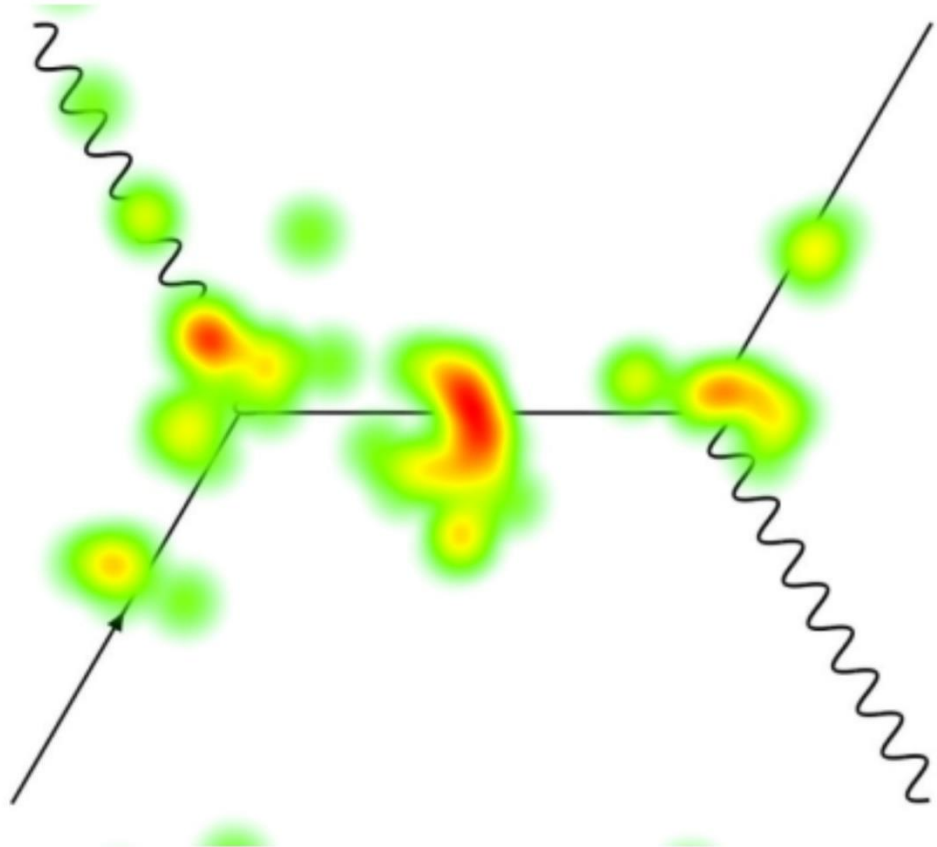
Development of
interest in partic
students' interes
contexts to ...

- define interest
- give recommen
material

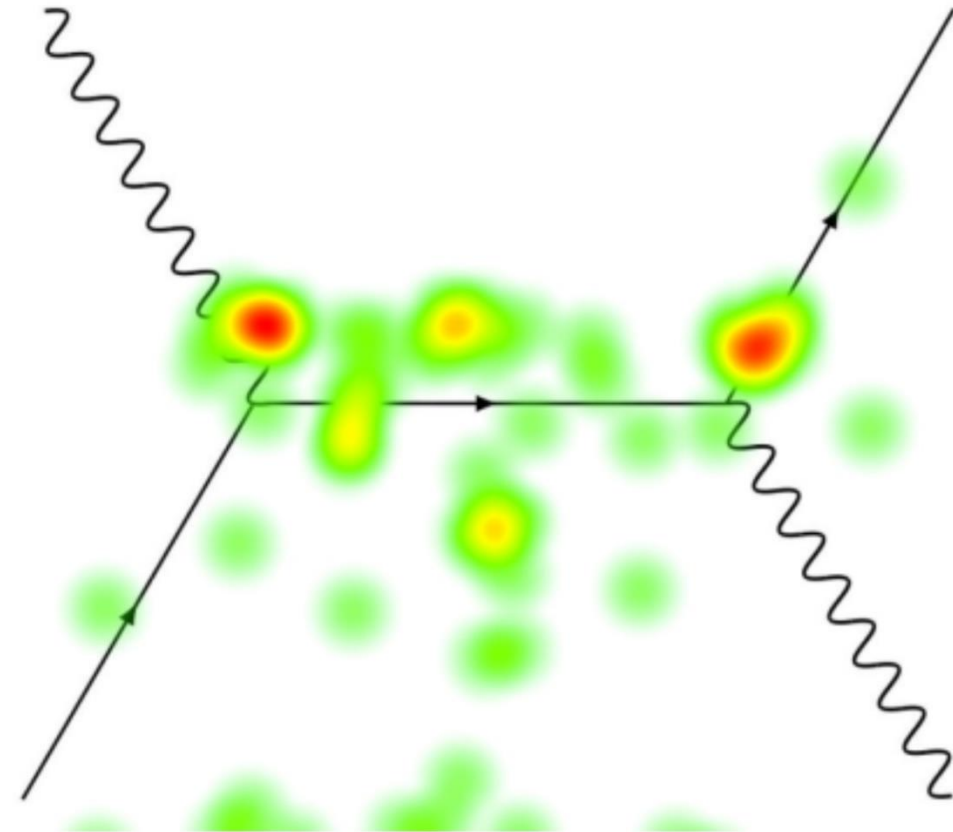


Eye Tracking in PER


Novices



Experts



How many Vertices is the diagram composed of?



HANDS-ON PHYSICS

- ⦿ HOP is a project of CERN in collaboration with INFN and Fondazione Agnelli.
- ⦿ It aims to empower Italian Middle school teachers to integrate physics hands-on activities in their lessons.

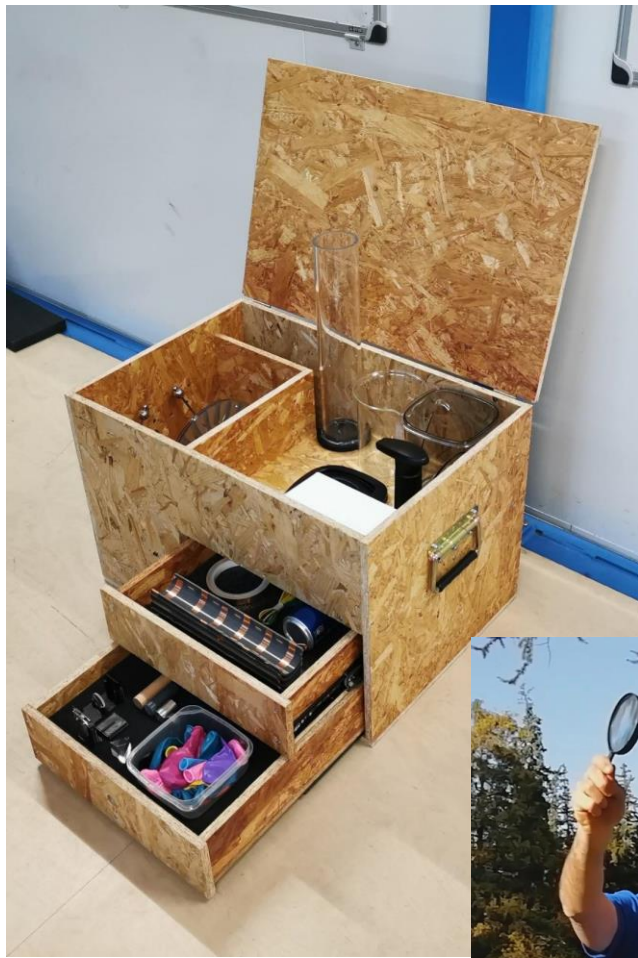
Why?

The science curriculum in middle school includes several topics, and Physics often receive less attention than other subjects.

How?

More than 1500 teachers from all over Italy will have the possibility to:

- ⦿ Receive a kit for experimental activities in their classroom.
- ⦿ Take part in a teacher training class.



The **kit** will consists in a unique box containing all the items to perform experiments on four different topics:

- ⊙ Scientific Method
- ⊙ Pressure
- ⊙ Light
- ⊙ Electricity

All the activities will be conducted using an inquiry based approach, based on the current research on physics education.



The teachers who will receive the kit will take part in a **teacher training session**.

Over a period of three years more than 40 sessions will be organised and they will cover the entire country.

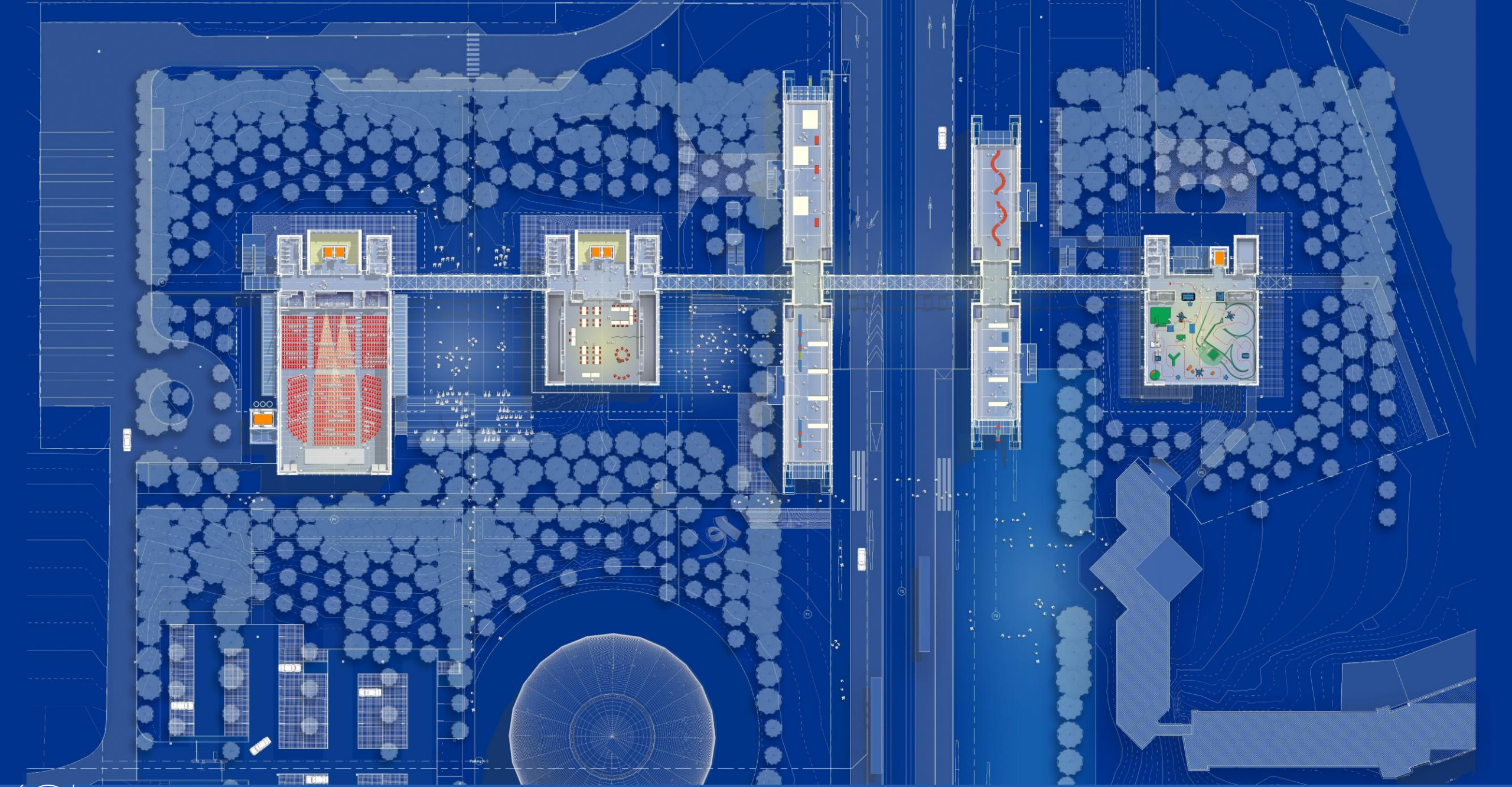
Goals:

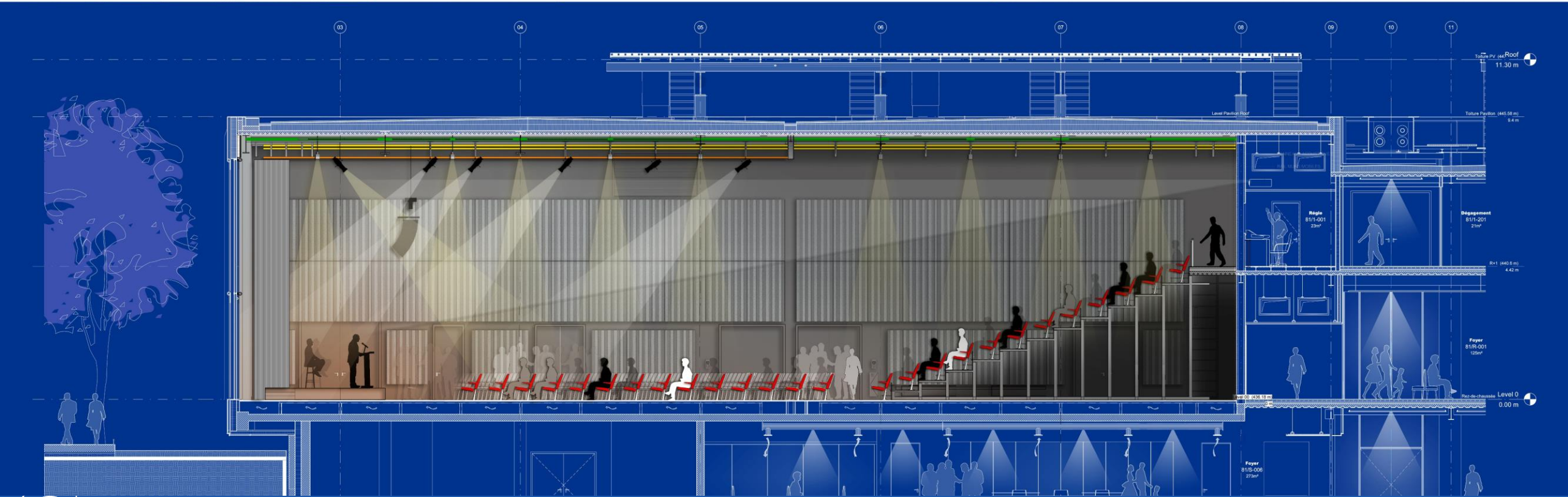
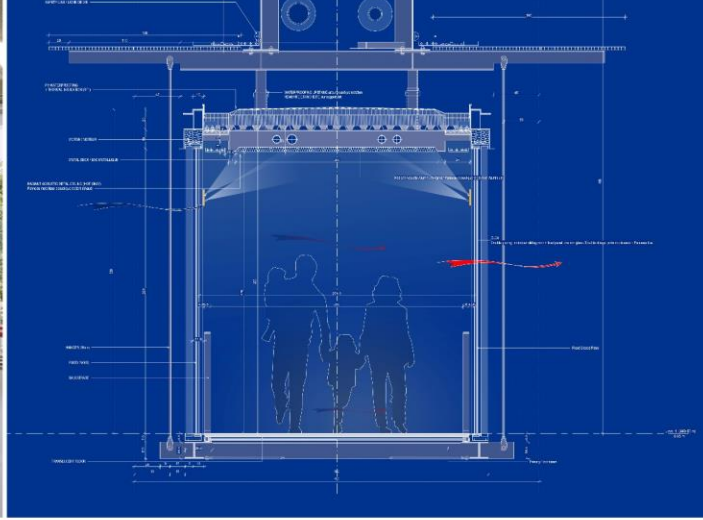
- ⊙ Getting familiar with the inquiry-based approach.
- ⊙ Exploring the kit and the activities included.



CERN Science Gateway







Ihre Fragen

