
CERN

CERN

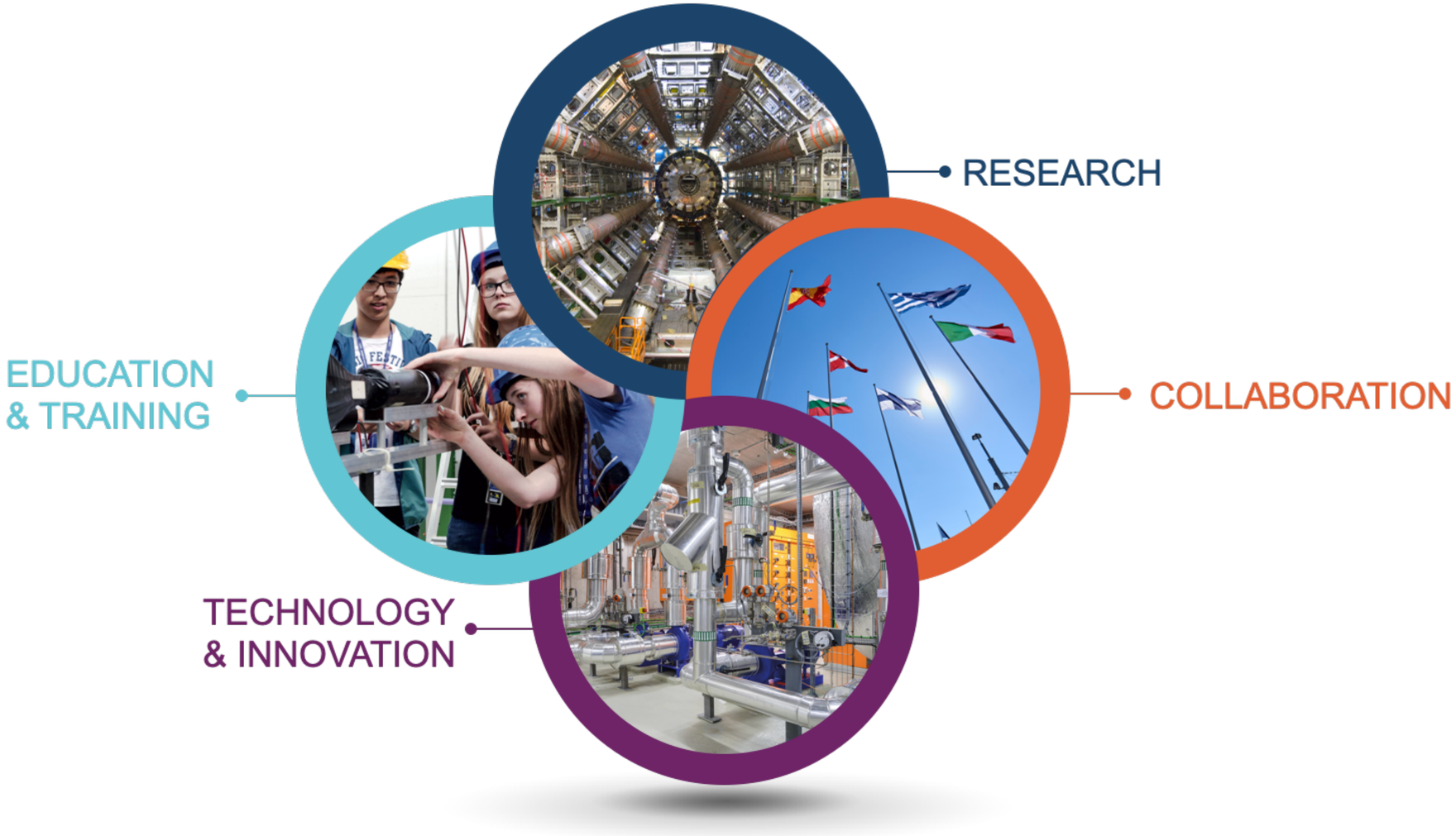
Past - Present - Future

Prof. Dr. Christoph Schäfer
CERN
Zagreb 4.12.2024

Contents

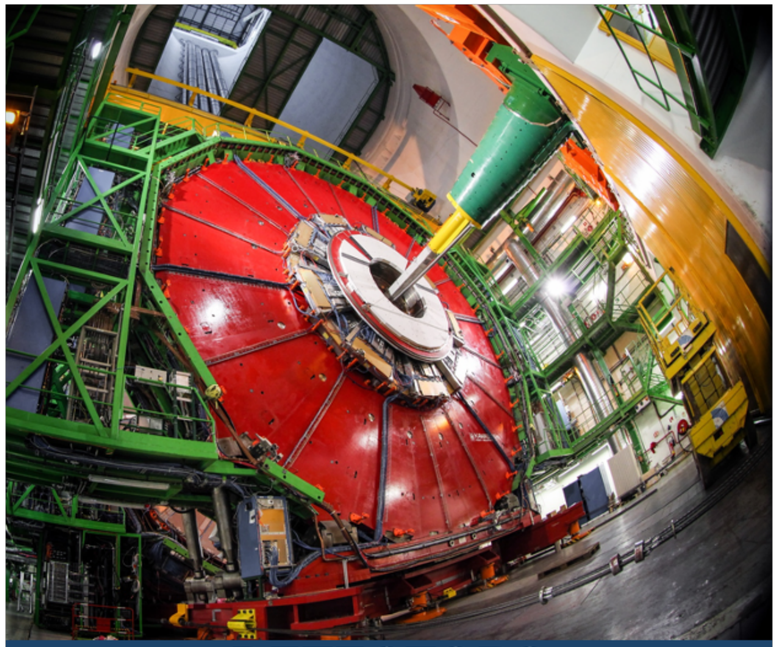
- CERN: What are we and what is our Mission?
- A brief History of CERN
- What is the future for CERN?

The Mission of CERN



CERN: Our Core Competences

ACCELERATORS



DETECTORS

COMPUTING

CERN: Science for Peace since 1954

Distribution of all CERN Users by the country of their home institutes as of 31 December 2023

Geographical & cultural diversity
Users of **110 nationalities**
22.5 % women

Member States 7467

Austria 86 – **Belgium** 129 – **Bulgaria** 46 – **Czech Republic** 252
Denmark 47 – **Estonia** 29 – **Finland** 88 – **France** 842 – **Germany** 1296
Greece 112 – **Hungary** 80 – **Israel** 74 – **Italy** 1609 – **Netherlands** 167
Norway 77 – **Poland** 322 – **Portugal** 105 – **Romania** 113
Serbia 38 – **Slovakia** 67 – **Spain** 413 – **Sweden** 106
Switzerland 419 – **United Kingdom** 950

Associate Member States in the pre-stage to membership **40**

Cyprus 14 – **Slovenia** 26

Associate Member States **541**

Brazil 135 – **Croatia** 37 – **India** 145 – **Latvia** 21 – **Lithuania** 17 – **Pakistan** 30
Türkiye 129 – **Ukraine** 27

Observers **2519**

Japan 219 – **JINR** (suspended) 293 – **United States of America** 2007

Non-Member States and Territories 1303

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Malaysia 4 – **Malta** 1 – **Mexico** 56 – **Montenegro** 3 – **Morocco** 18 – **New Zealand** 2 – **Nigeria** 2 – **Oman** 1
Palestine 1 – **Peru** 3 – **Philippines** 1 – **Republic of Korea** 168 – **Saudi Arabia** 6 – **South Africa** 61 – **Sri Lanka** 10
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CERN's annual budget is 1200 MCHF (equivalent to a medium-sized European university)

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Employees:
2666 staff, **1002** graduates
Associates:
12 370 users, **1513** others

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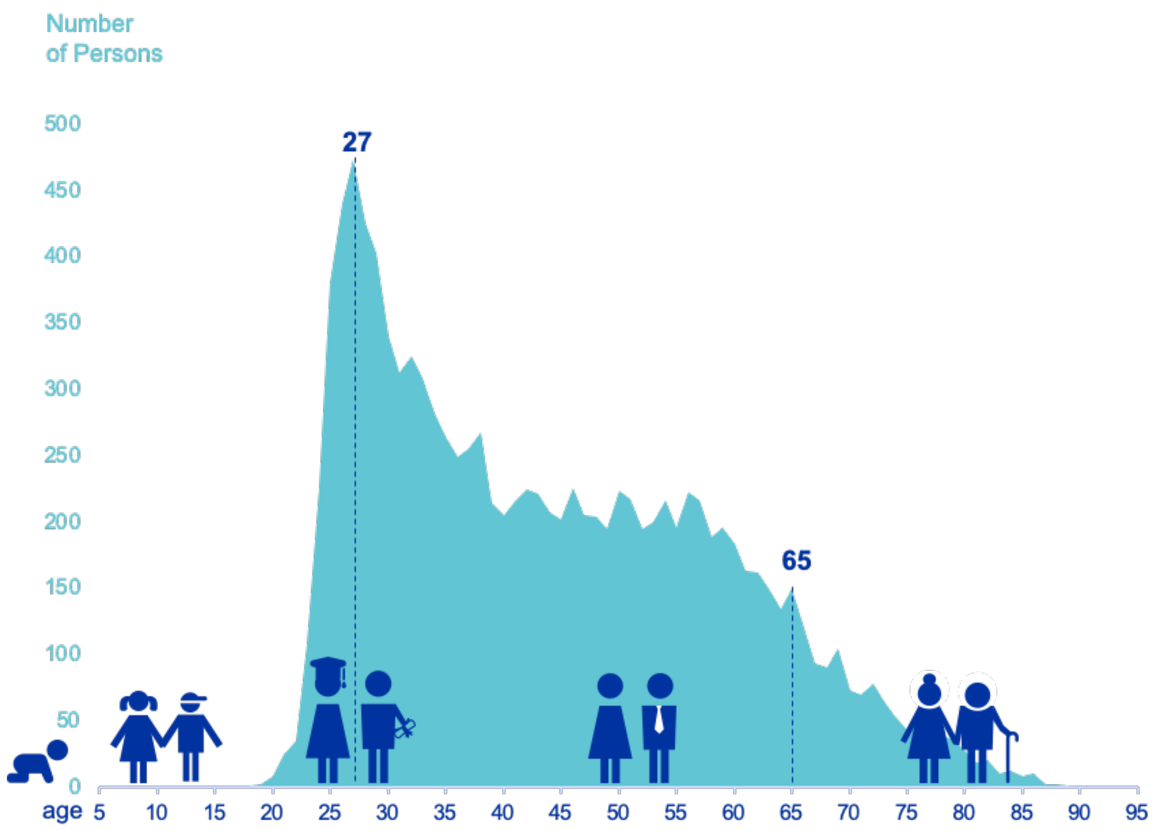
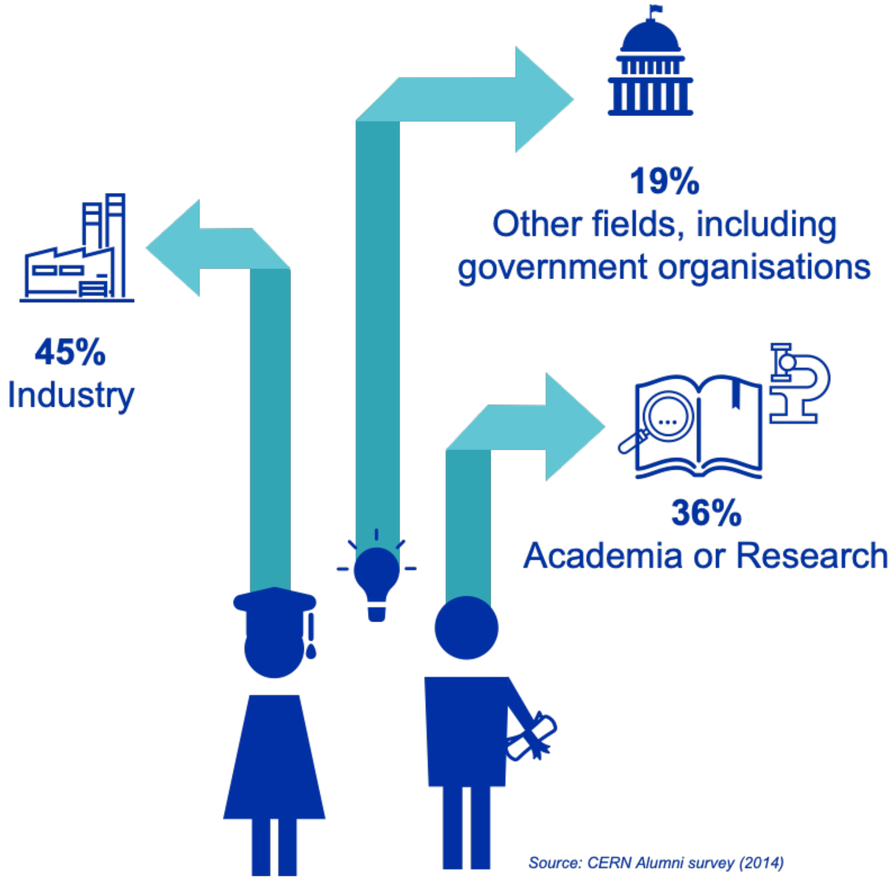
A world of career opportunities



Age Distribution of Scientists working at CERN



PhD and Technical students leaving CERN

CERN Education & Outreach

1002 graduates
(including Research Fellows)

3 000 PhD students

300 Undergraduate students in Summer programmes

> 15 000 teachers participating in dedicated programmes, since 1998

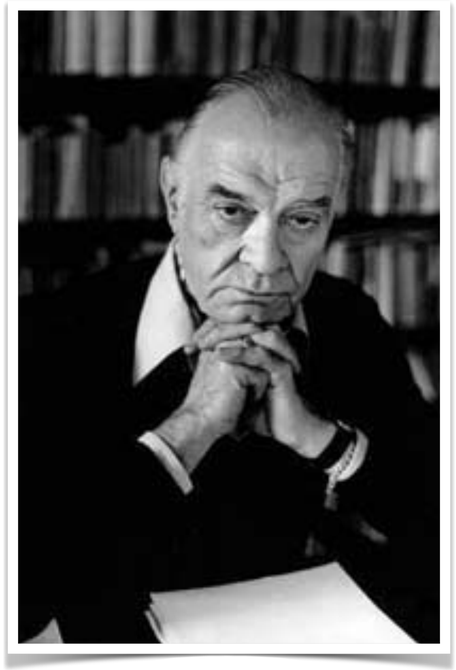
Around **150 000 visitors** per year on guided tours of CERN, from >50 countries

4.7M followers on social media, from around the globe

A brief History of CERN

1949: The Origins of CERN

- European science was depleted after the war
- Nuclear scientists wanted to do something for peace
- Political and scientific consensus
- Denis de Rougemont and Louis de Broglie put forward a proposal at the European Cultural Conference in Lausanne in 1949

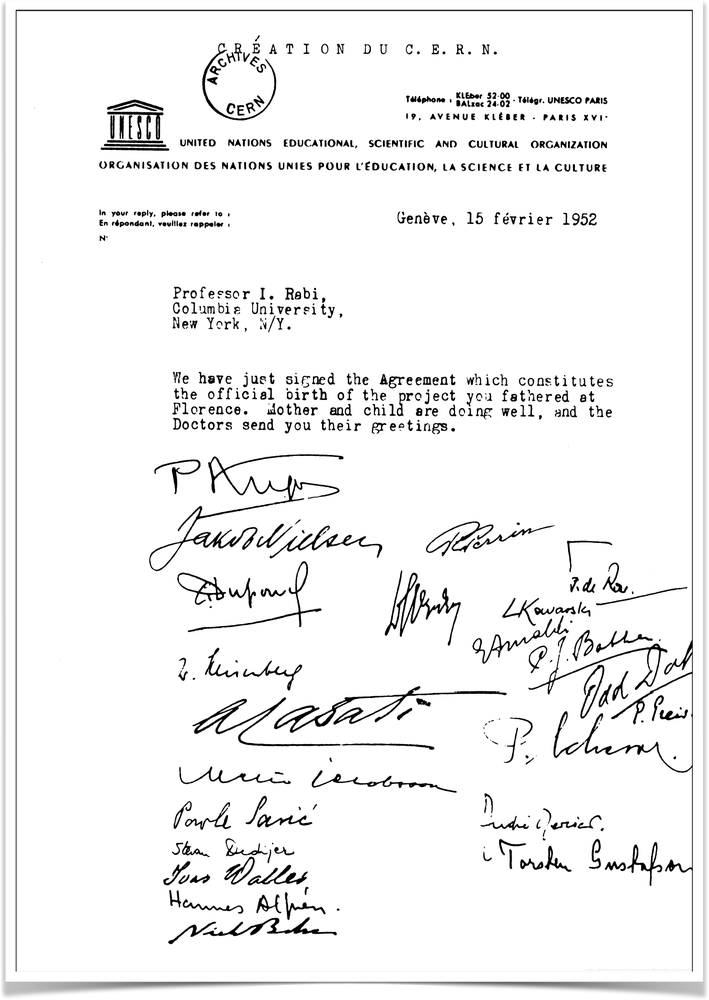


1950: UNESCO

At the UNESCO General Conference in Florence, American Noble laureate, Isidor Rabi tables a resolution authorising UNESCO to:

“assist and encourage the formation of regional research laboratories in order to increase international scientific collaboration …”

1951: UNESCO



CRÉATION DU C. E. R. N.

ARCHIVES CERN

UNESCO

Téléphone : KLÉber 52-00 - Télégr. UNESCO PARIS
19, AVENUE KLÉBER - PARIS XVI[e]

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
ORGANISATION DES NATIONS UNIES POUR L'ÉDUCATION, LA SCIENCE ET LA CULTURE

In your reply, please refer to :
En répondant, veuillez rappeler :
N°

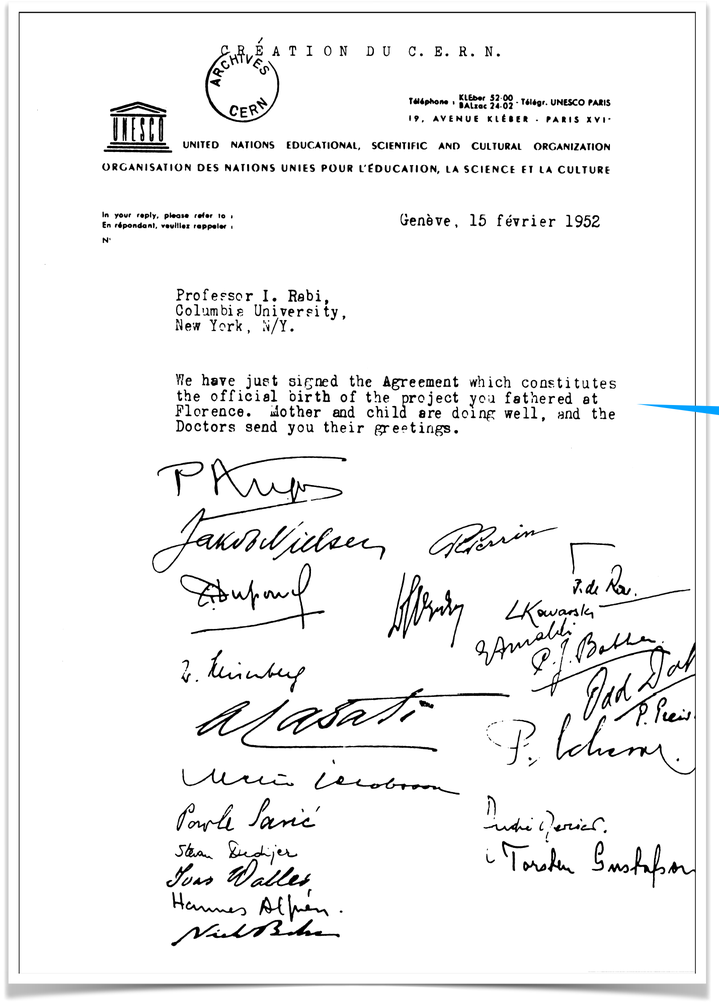
Genève, 15 février 1952

Professor I. Rabi,
Columbia University,
New York, N/Y.

We have just signed the Agreement which constitutes the official birth of the project you fathered at Florence. Mother and child are doing well, and the Doctors send you their greetings.

At a meeting of UNESCO in Paris in December 1951, the first resolution concerning the establishment of a European Council for Nuclear Research was adopted. Two months later, 11 countries signed an agreement establishing the provisional Council - the acronym CERN was born.

1951: UNESCO



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At a me… …ember 195… …he e… N… la… esta… …he acronym

We have just signed the Agreement which constitutes the official birth of the project you fathered at Florence. Mother and child are doing well, and the Doctors send you their greetings

1952: The choice of Geneva

Sur le terrain du futur institut nucléaire

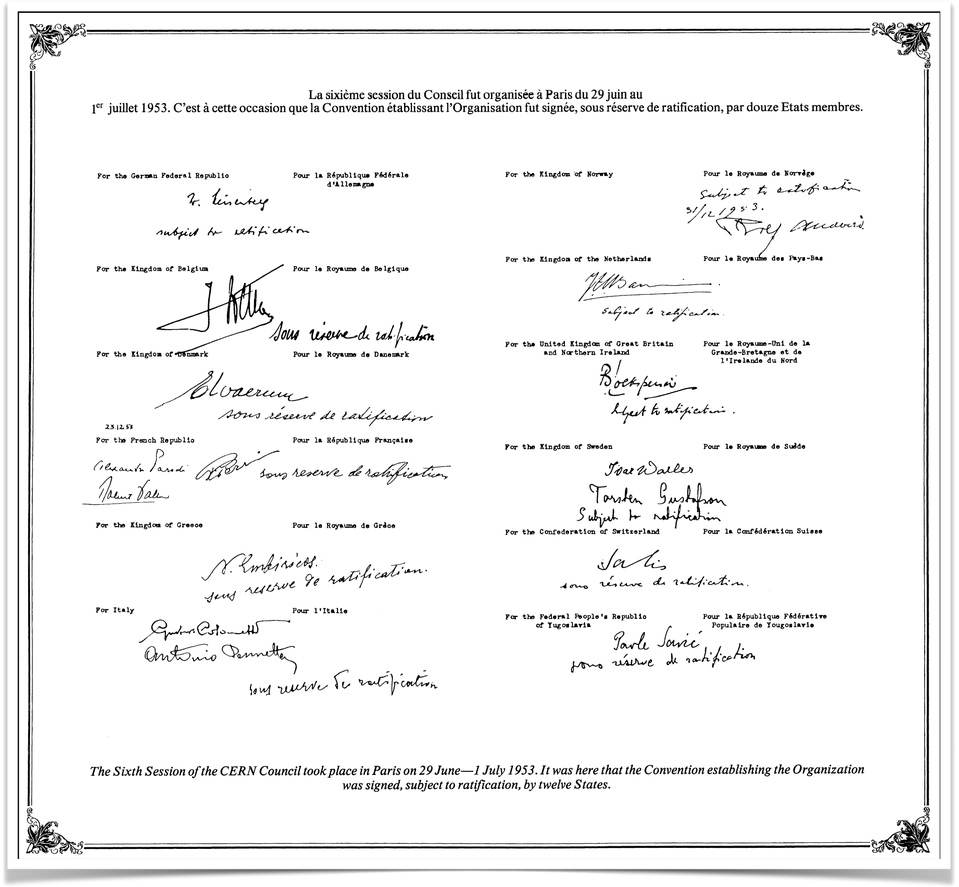
Sous la conduite de M. A. Picot, les membres du Conseil européen pour la recherche nucléaire se sont rendus hier à Meyrin pour reconnaître le terrain où s'élèvera le Centre nucléaire (voir en Dernière heure)

(Photo Freddy Bertrand, Genève)

La Suisse du 30 octobre 1953

At the provisional Council's third session in October 1952, Geneva was chosen as the site of the future Laboratory. This choice was finally ratified in a referendum organized by the Canton of Geneva in June 1953.

1954: The Organization is Born



La sixième session du Conseil fut organisée à Paris du 29 juin au 1er juillet 1953. C'est à cette occasion que la Convention établissant l'Organisation fut signée, sous réserve de ratification, par douze Etats membres.

For the German Federal Republic — Pour la République Fédérale d'Allemagne
subject to ratification

For the Kingdom of Belgium — Pour le Royaume de Belgique
sous réserve de ratification

For the Kingdom of Denmark — Pour le Royaume de Danemark
sous réserve de ratification
23.12.53

For the French Republic — Pour la République Française
sous reserve de ratification

For the Kingdom of Greece — Pour le Royaume de Grèce
sous reserve de ratification.

For Italy — Pour l'Italie
sous reserve de ratification

For the Kingdom of Norway — Pour le Royaume de Norvège
Subject to ratification
31/12/1953.
Accepted

For the Kingdom of the Netherlands — Pour le Royaume des Pays-Bas
subject to ratification.

For the United Kingdom of Great Britain and Northern Ireland — Pour le Royaume-Uni de la Grande-Bretagne et de l'Irlande du Nord
Subject to ratification.

For the Kingdom of Sweden — Pour le Royaume de Suède
Subject to ratification

For the Confederation of Switzerland — Pour la Confédération Suisse
sous réserve de ratification.

For the Federal People's Republic of Yugoslavia — Pour la République Fédérative Populaire de Yougoslavie
sous réserve de ratification

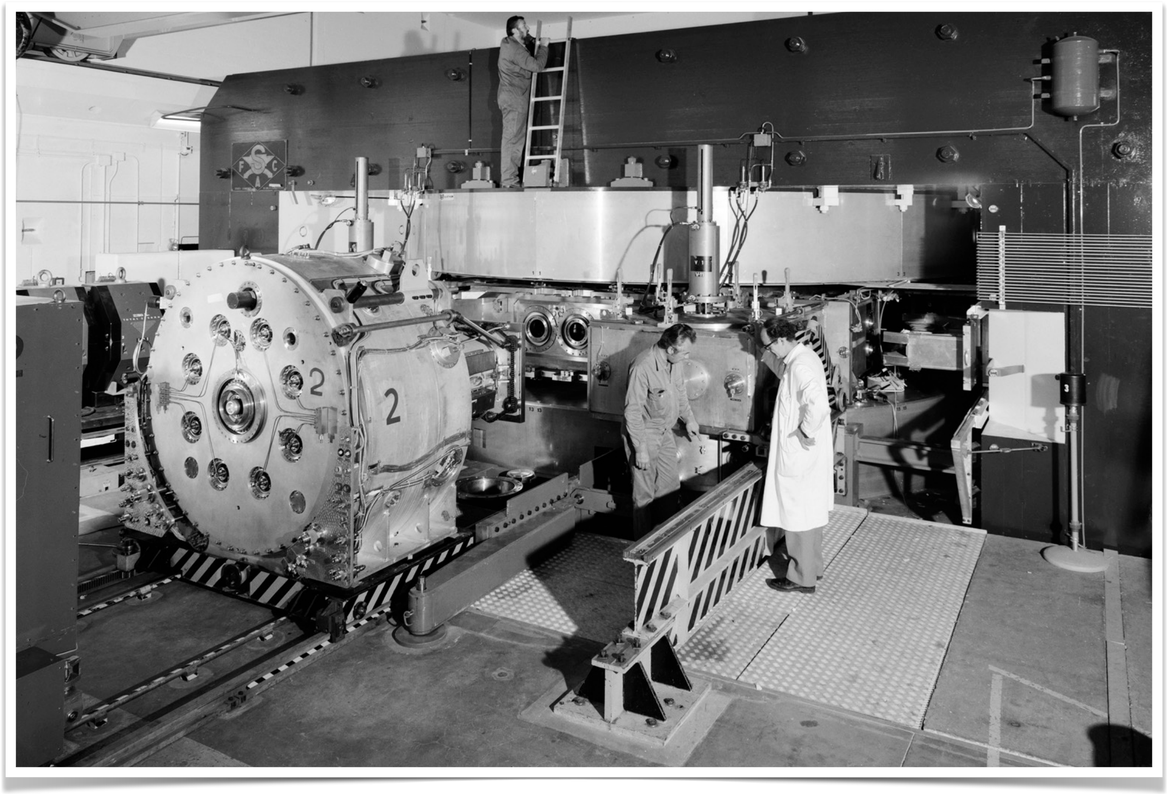
The Sixth Session of the CERN Council took place in Paris on 29 June—1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by twelve States.

The CERN Convention, established in July 1953, was ratified by the 12 founding Member States: Belgium, Denmark, France, the Federal Republic of Germany, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland, the UK, and Yugoslavia. On 29 September 1954, the European Organization for Nuclear Research officially came into existence.

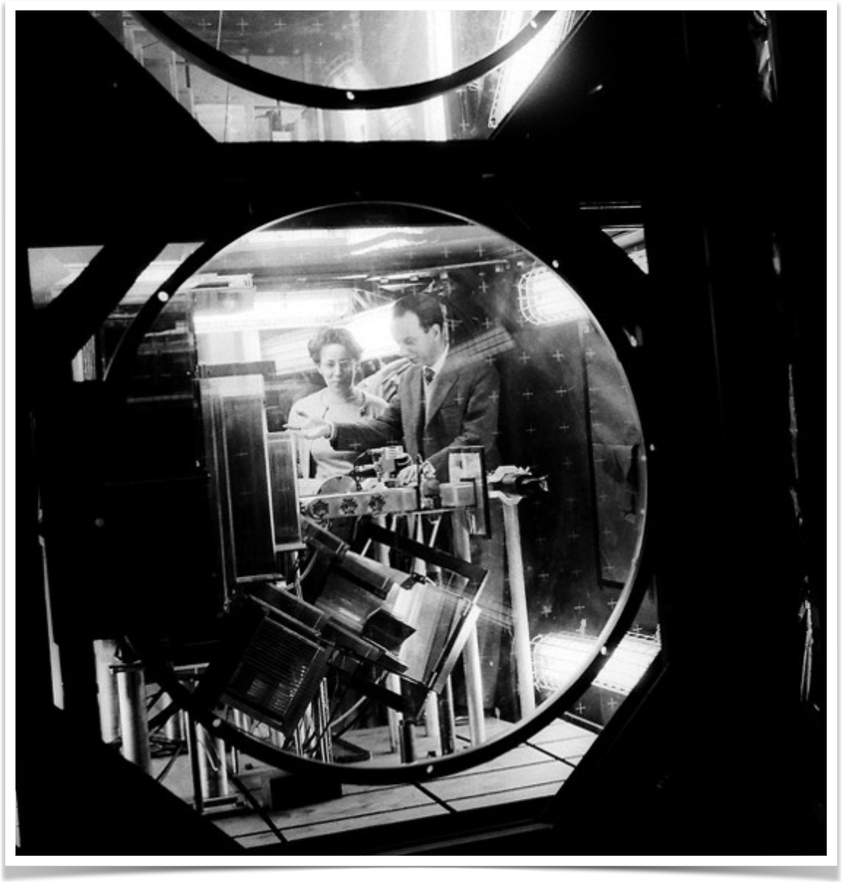
CERN was dissolved but the acronym remains.

1957: CERN's first accelerator: The Synchrocyclotron

Transport of the coil



1958: CERN’s first experiment

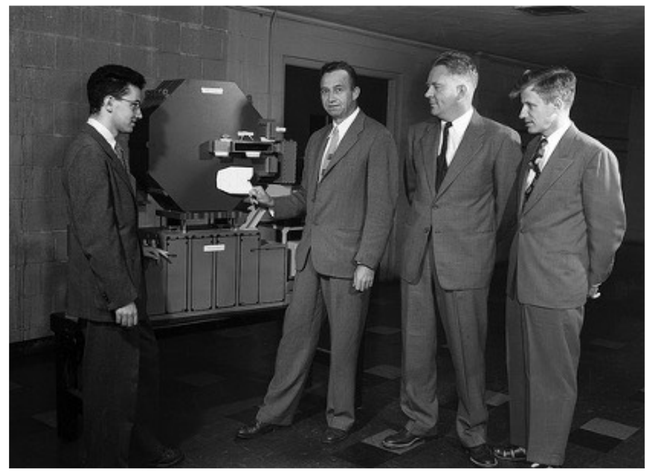


July 1958:
Evidence that one pion in ten thousdands decayed into an electron and a neutrino as predicted by the weak interaction.
The first of CERN’s great discoveries.

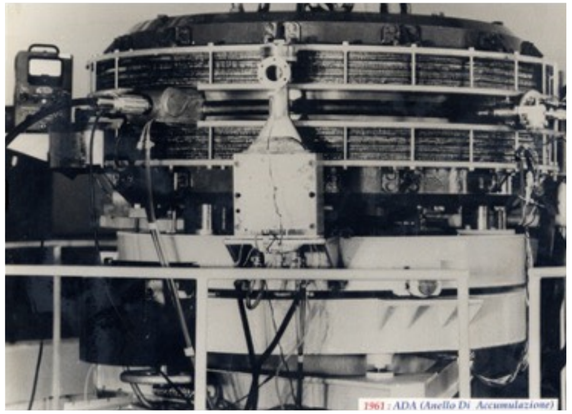
1959: CERN's first big machine

Start up of the CERN Proton Synchrotron, assisted by Hildred Blewett from Brookhaven….

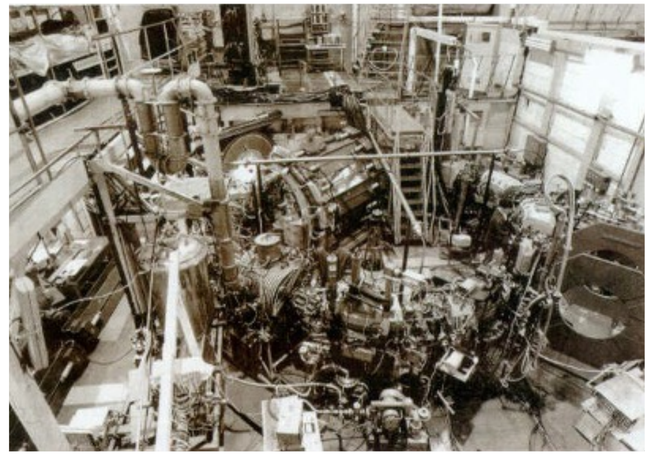
… who shared the technique of strong focusing, invented at Brookhaven, with her European colleagues.



The late 1950s saw the healthy competitive collaboration between the US and Europe that continues to this day…

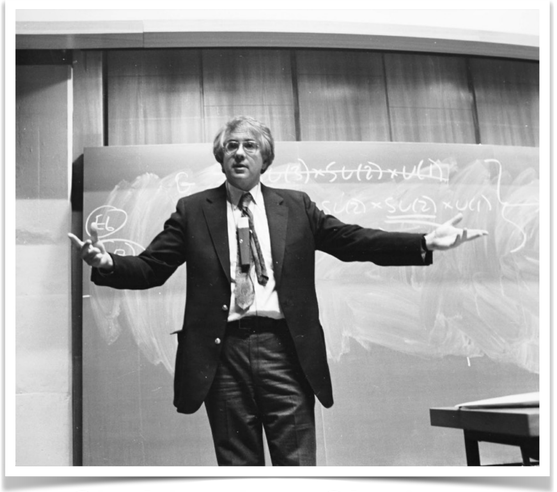


1961: ADA at Frascati…



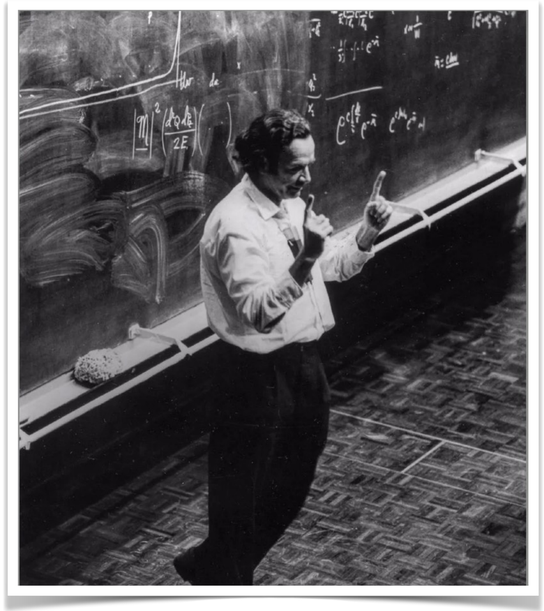
… and VEPP-1 at Novosibirsk

1960s: Advances in theory

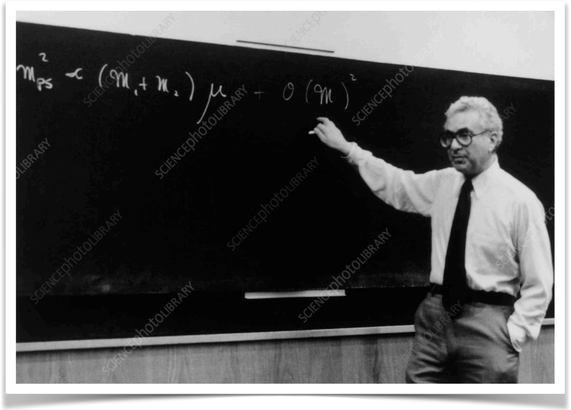


Sheldon Lee Glashow

Francois Englert & Peter Higgs

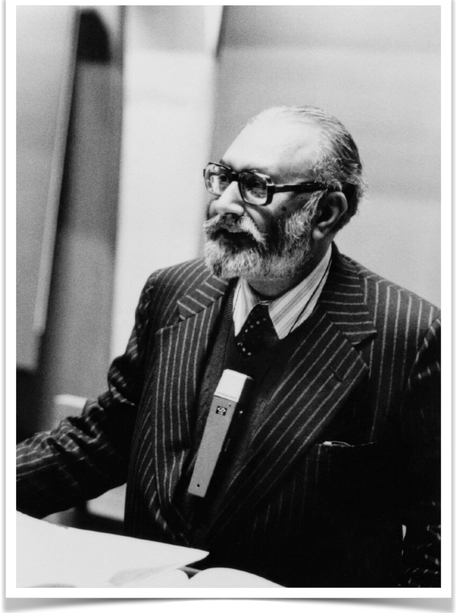


Richard Feynman



Murray Gell-Mann

Steven Weinberg



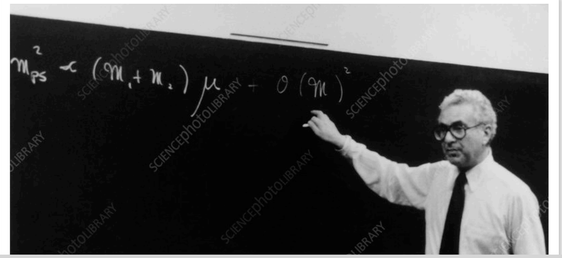
Abdus Salam

1960s: Advances in theory

Giving Seminars at CERN

Sheldon Lee Glashow

Richard Feynman



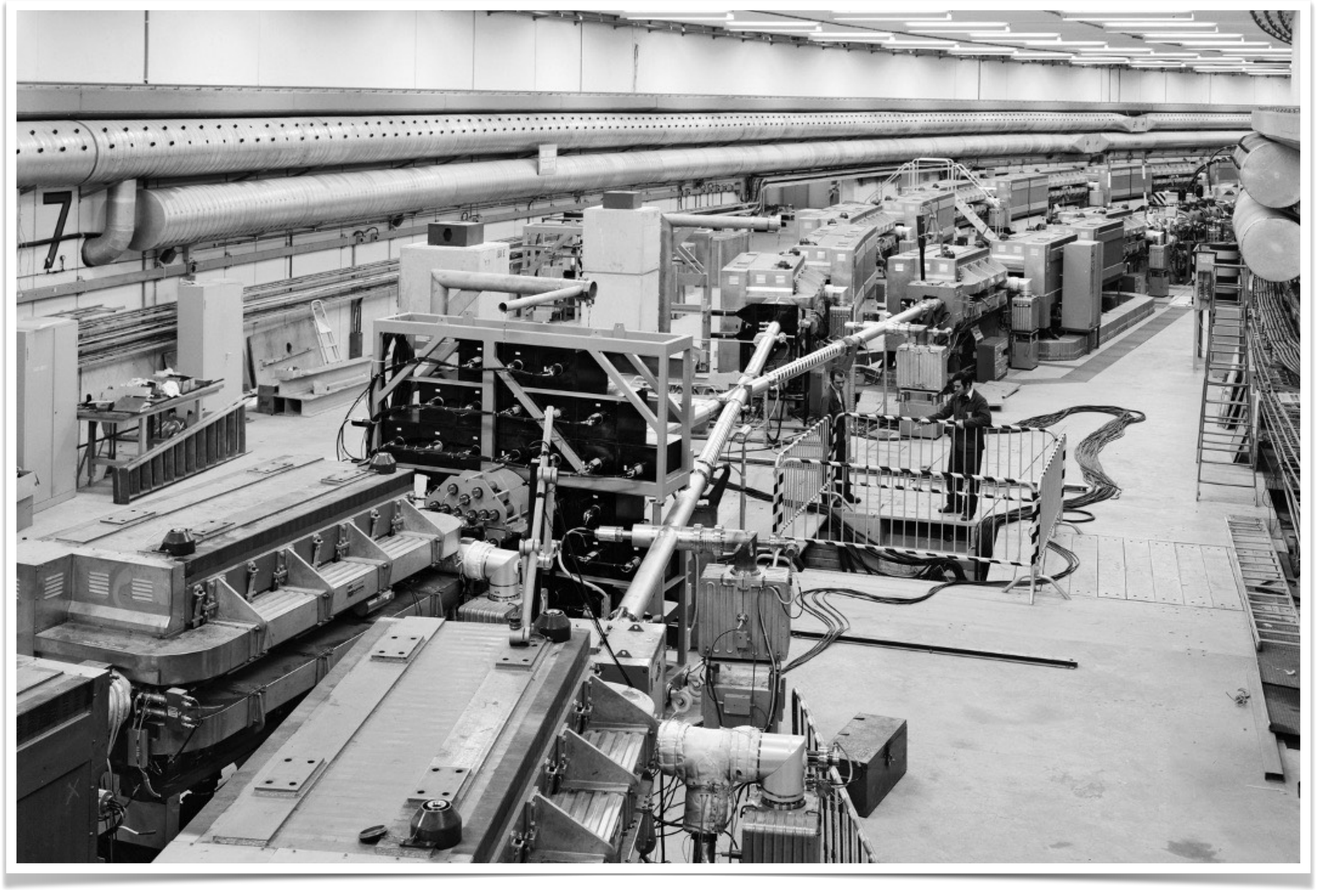
Murray Gell-Mann

Abdus Salam

Francois Englert & Peter Higgs

Steven Weinberg

1965: Approval of the ISR: The world's first hadron collider



1967: Looking to the East…

In 1967, CERN signed an agreement with the USSR that led to exchanges of personnel and equipment between CERN and Serpukhov.

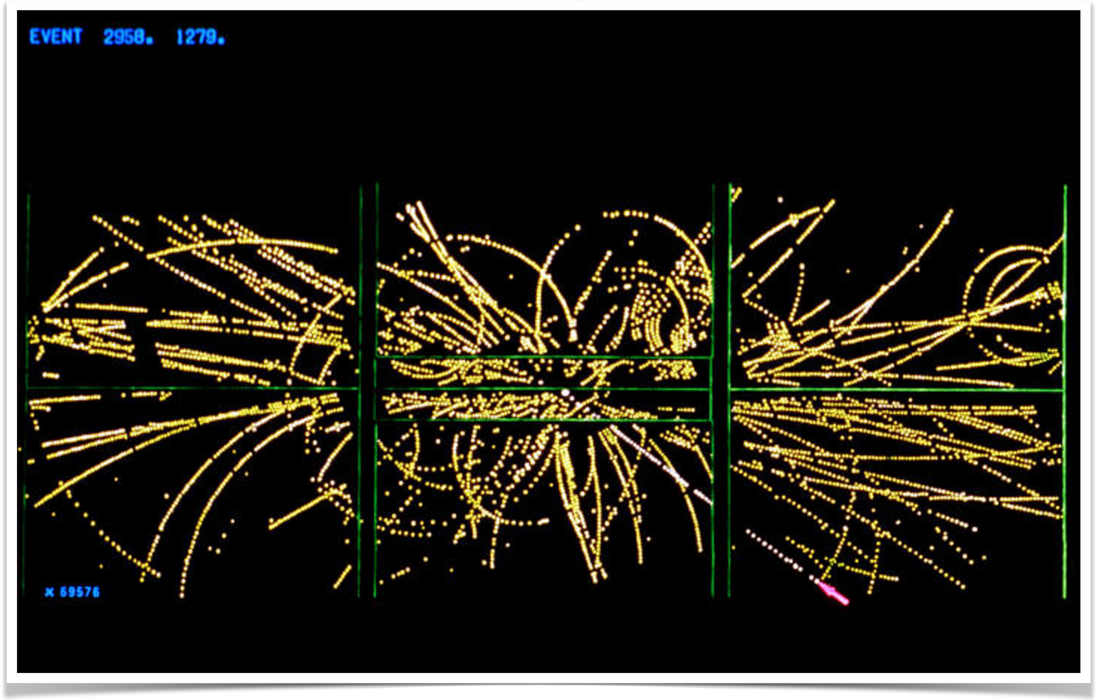
This Antonov 22 transporter caused quite a stir when it arrived at Geneva airport in 1970.
A top-secret military aircraft, its first mission beyond the Soviet Union was to collect a state-of-the-art experiment from CERN and take it to Russia where it was to be installed at the worlds' highest energy particle accelerator at the time in Serpukhov.

Earlier in the decade, CERN had been the scene of the first scientific contacts between East and West Germany following the erection of the Berlin wall..

1967: The arrival of a new friendly rival: Fermilab

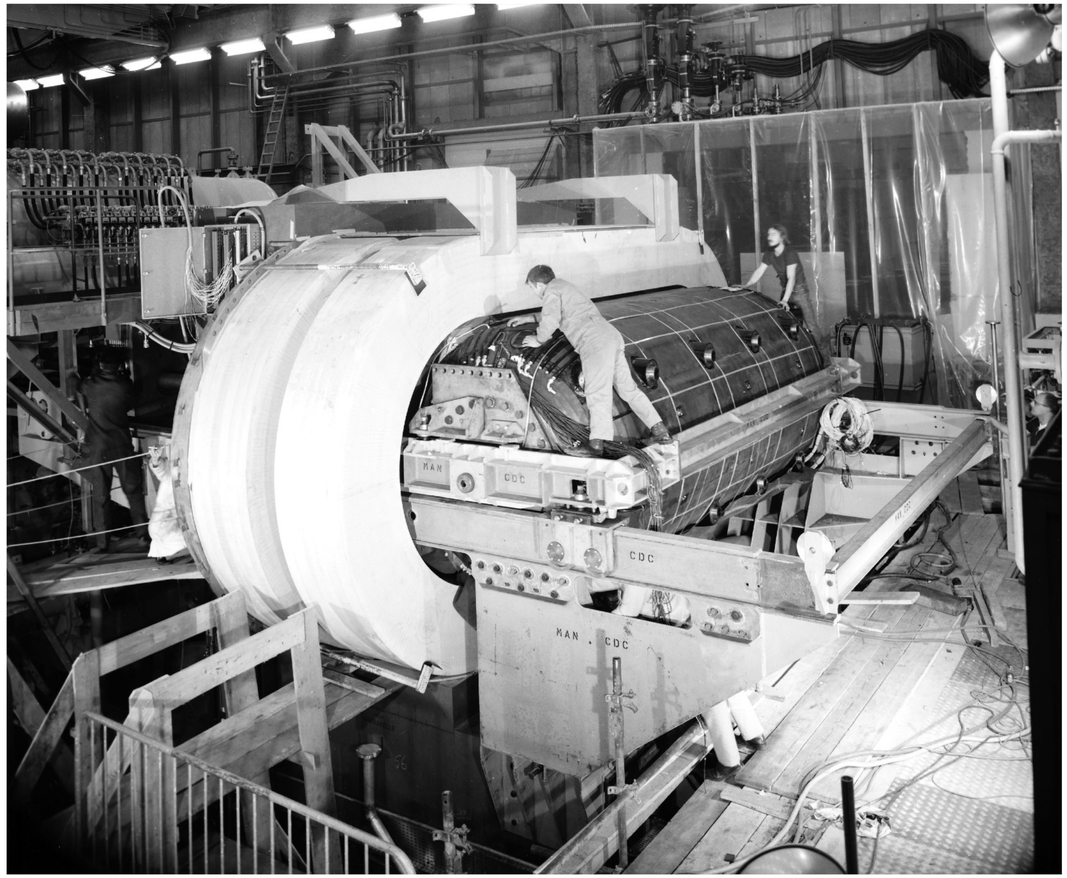
1968: Multi-wire proportional chamber: Revolutionising the way particle physics is done

Before: Scanning of images by hand

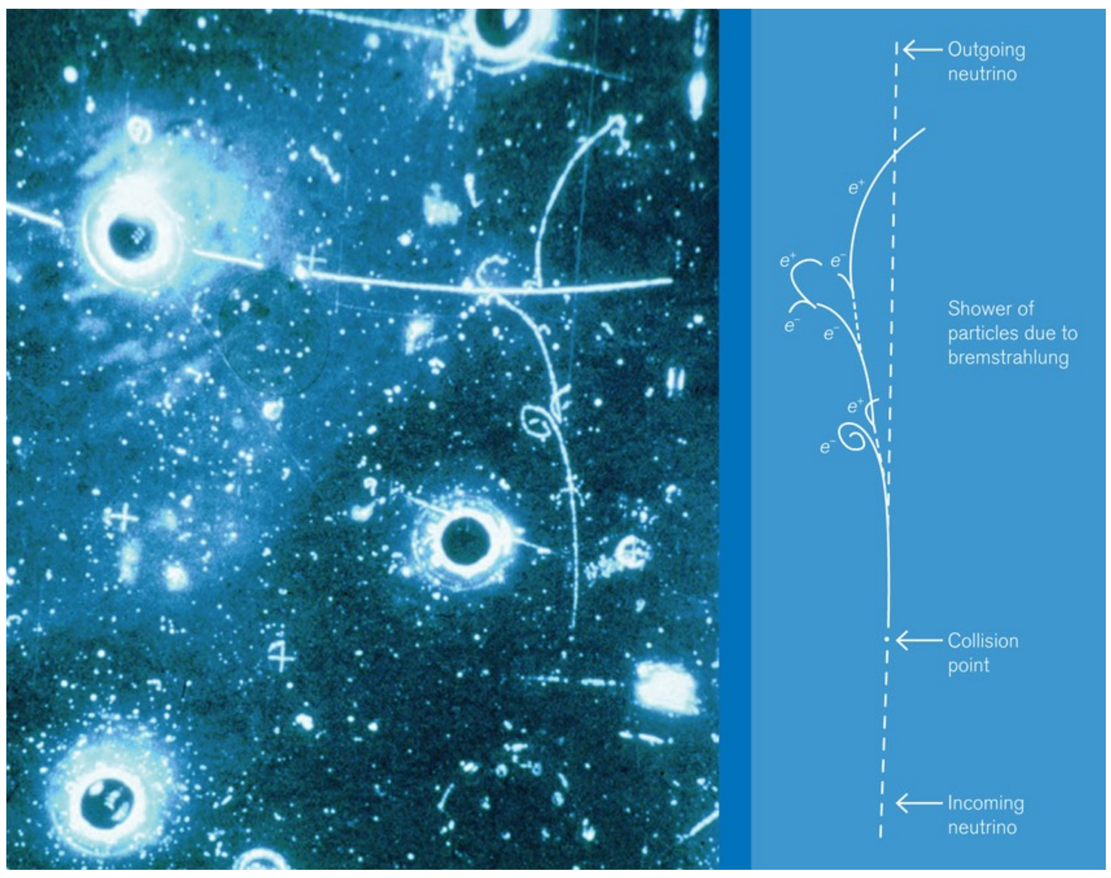


Now: automatic digital images

1973: Discovery of Neutral currents



Gargamelle Bubble Chamber



Discovery of weak neutral current

1976: The SPS begins operation

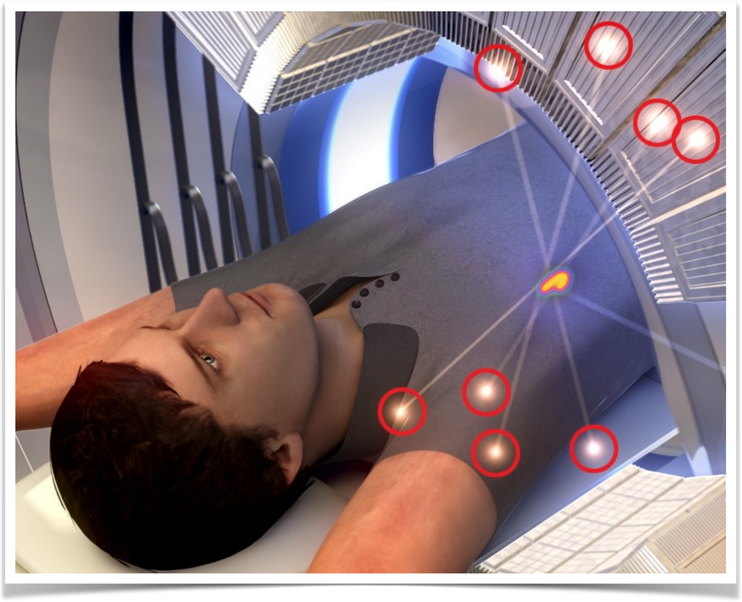
The PS becomes super:

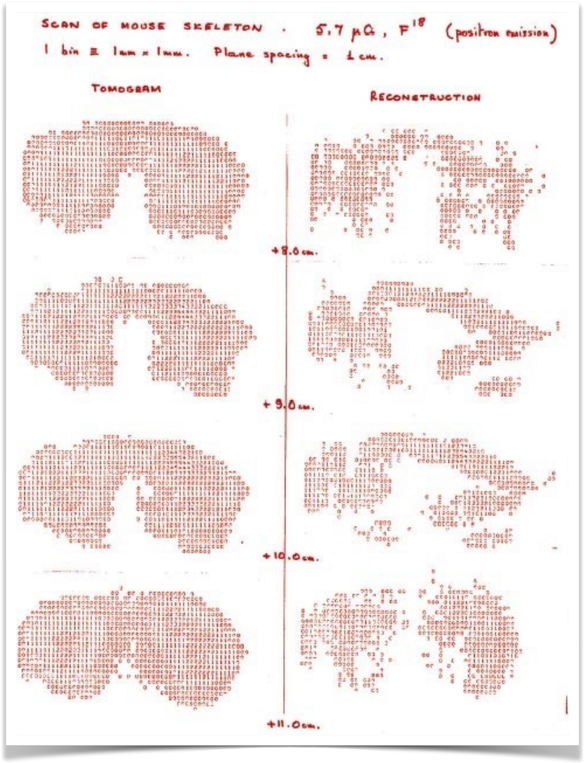
CERN needed to extent its premisses into France

1977: CERN built a detector for a hospital

PET: Positron Emission Tomography

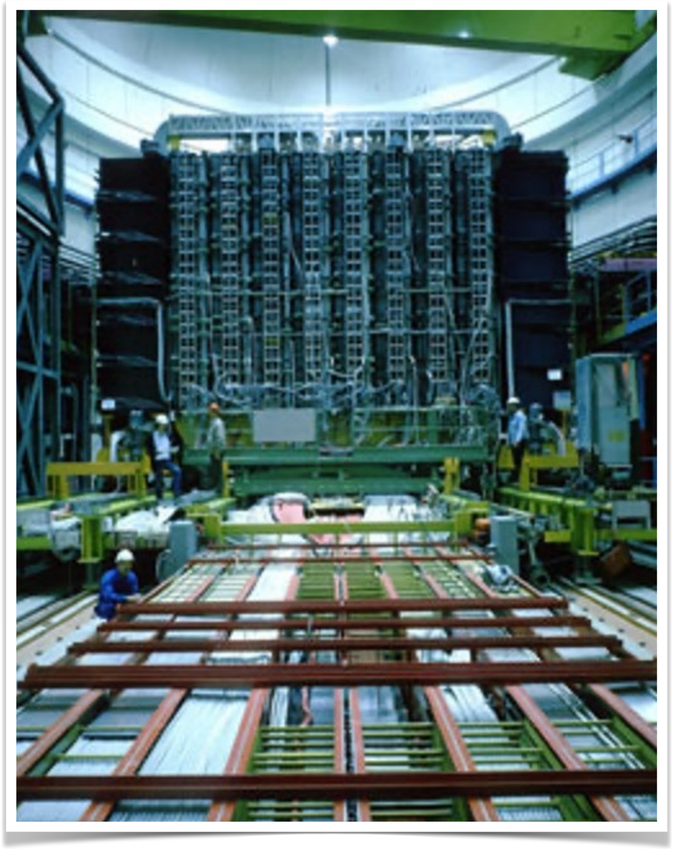
Detection of two photons
created during matter-antimatter annihilation
in the human body





First PET image at CERN

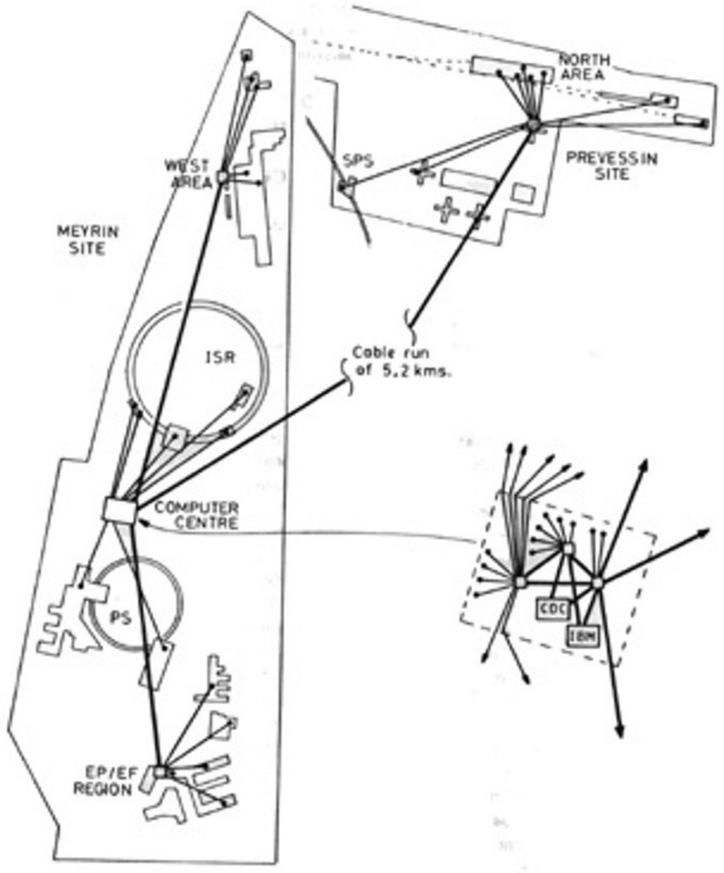
1983: CERN's first golden age



UA1 detector

- The SPS working as a collider discovers the W and Z particles, mediators of the weak interaction.
- This experimental confirmation of the electroweak theory leads to the award of the Nobel prize the following year…
- … and continues CERN's tradition of electroweak science.

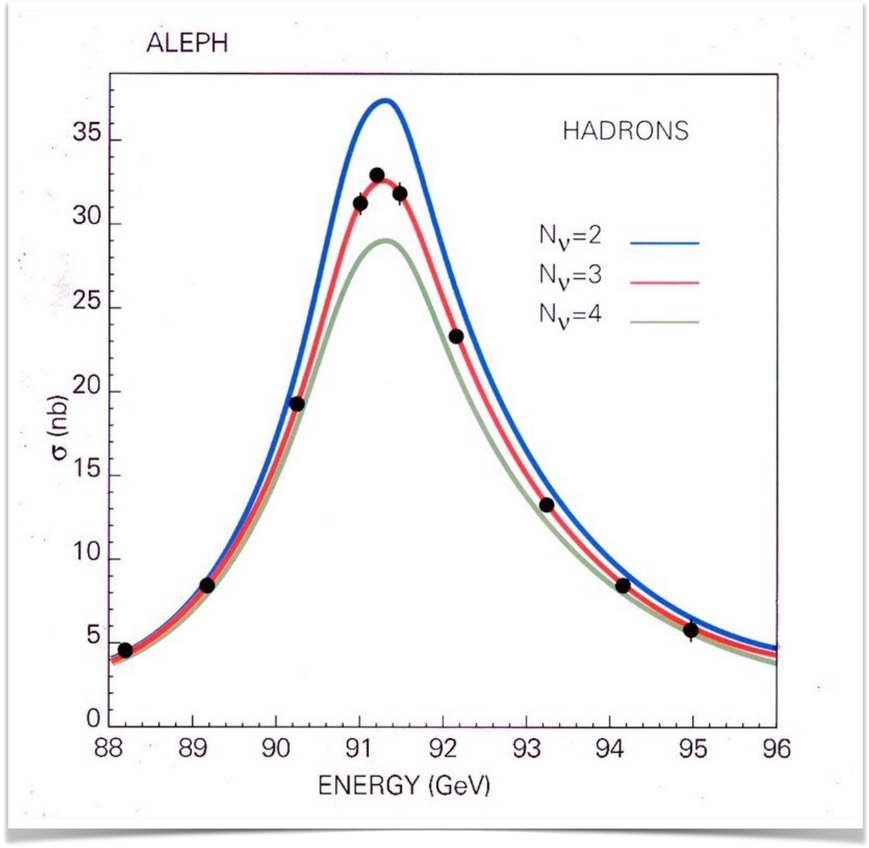
1987: CERNET gives way to INTERNET



CERN Computer Centre

1989: LEP and SLC
Circle or linear

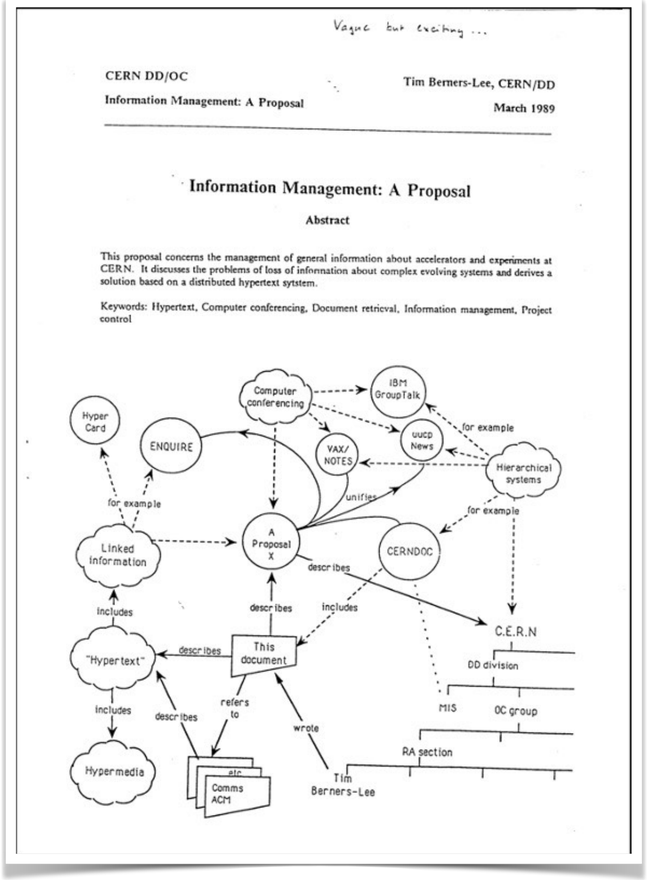
1989: LEP and SLC
The W and Z factories



Unprecedented precision measurement

The Z line shape, error bars hardy visible!

1989: The WWW



Vague but exciting ...

CERN DD/OC

Tim Berners-Lee, CERN/DD

Information Management: A Proposal

March 1989

Information Management: A Proposal

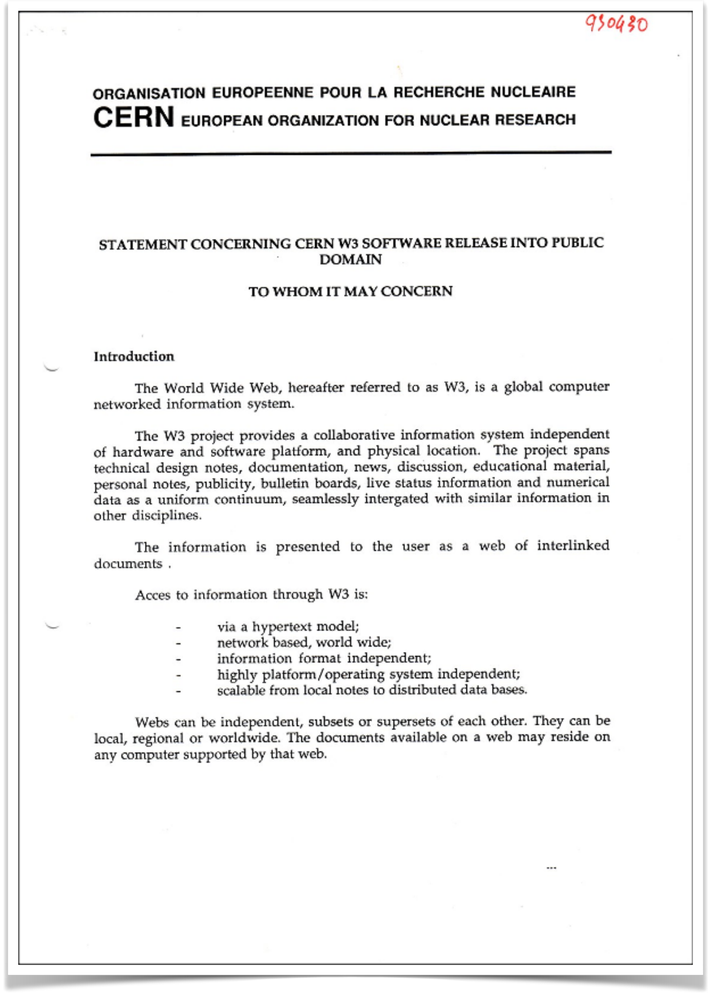
Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext sytstem.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control

Tim Berners Lee in front of his original NEXT computer

The most valuable document ever?



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ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

STATEMENT CONCERNING CERN W3 SOFTWARE RELEASE INTO PUBLIC DOMAIN

TO WHOM IT MAY CONCERN

Introduction

The World Wide Web, hereafter referred to as W3, is a global computer networked information system.

The W3 project provides a collaborative information system independent of hardware and software platform, and physical location. The project spans technical design notes, documentation, news, discussion, educational material, personal notes, publicity, bulletin boards, live status information and numerical data as a uniform continuum, seamlessly intergated with similar information in other disciplines.

The information is presented to the user as a web of interlinked documents .

Acces to information through W3 is:

- via a hypertext model;
- network based, world wide;
- information format independent;
- highly platform/operating system independent;
- scalable from local notes to distributed data bases.

Webs can be independent, subsets or supersets of each other. They can be local, regional or worldwide. The documents available on a web may reside on any computer supported by that web.

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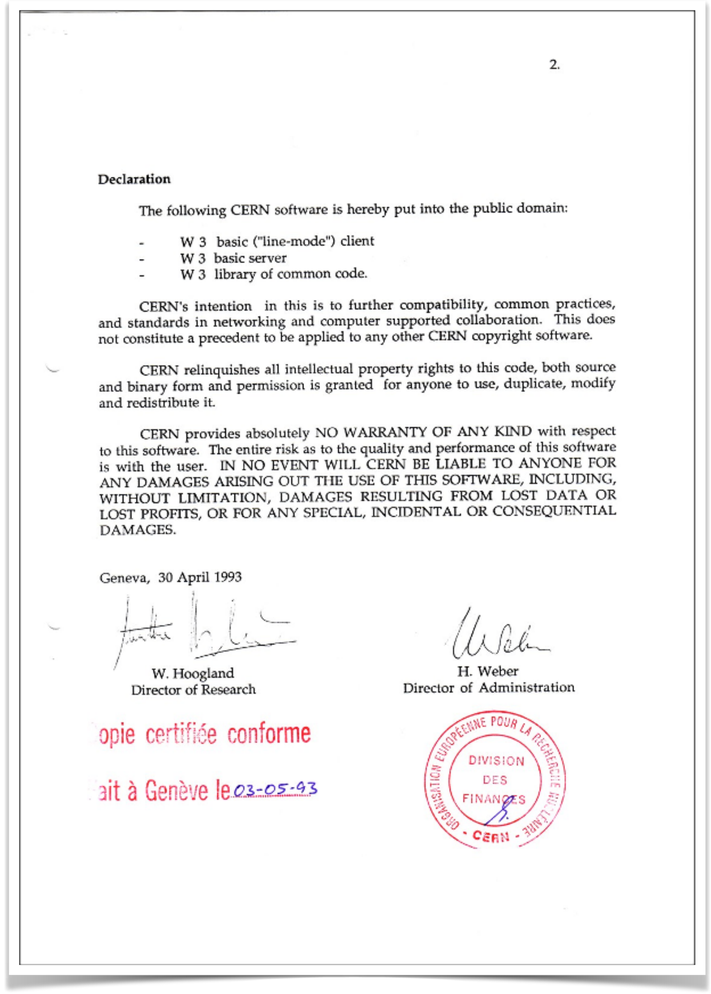

2.

Declaration

The following CERN software is hereby put into the public domain:

- W 3 basic ("line-mode") client
- W 3 basic server
- W 3 library of common code.

CERN's intention in this is to further compatibility, common practices, and standards in networking and computer supported collaboration. This does not constitute a precedent to be applied to any other CERN copyright software.

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Geneva, 30 April 1993

W. Hoogland
Director of Research

H. Weber
Director of Administration

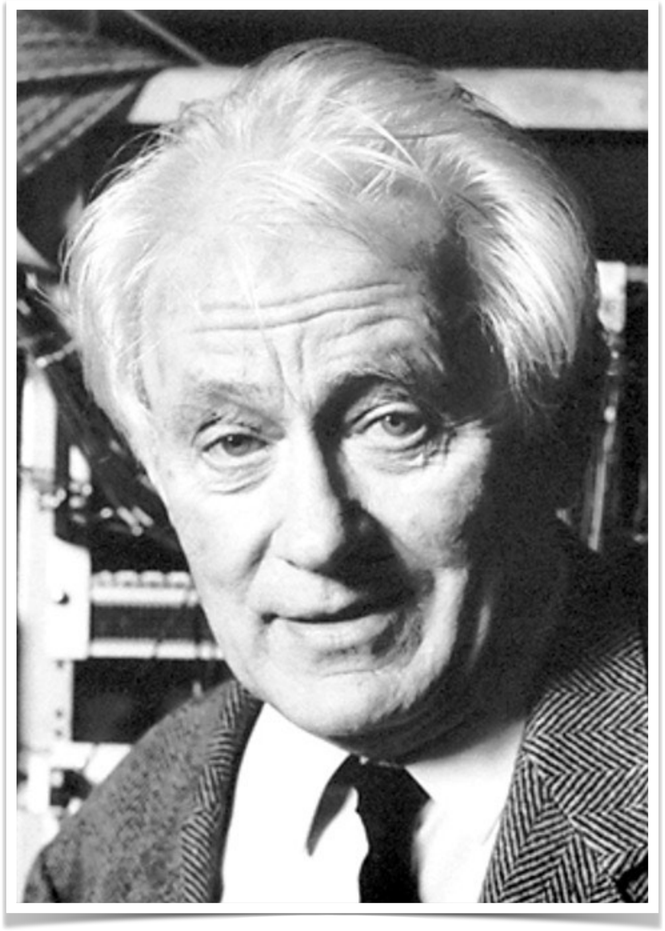
opie certifiée conforme

ait à Genève le 03-05-93

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
DIVISION DES FINANCES
CERN

Release of the WWW into public domaine

1992: George Charpak wins the Nobel Price



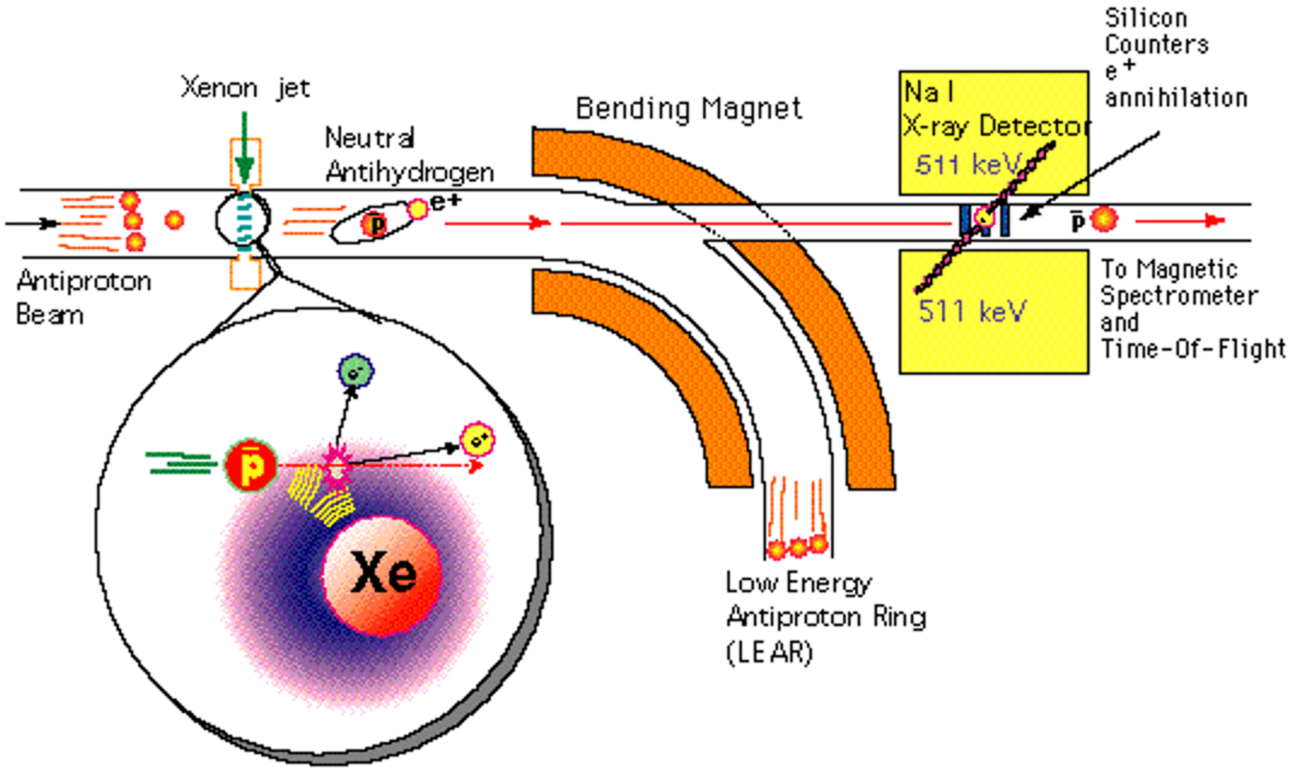
For the construction of the
Multi Wire Proportional Chamber

1993: A tiny preference for matter

- CERN experiment NA31 publishes the first indication at the particle level that nature has a preference for matter over antimatter… accompanied by Fermilab experiment E731.
- This result was refined in 2001 by NA48 at CERN and KTeV at Fermilab.

1995: First observation of Antihydrogen

LEAR: Low Energy Antiproton Ring



1995: A discovery at FERMILAB
The top quark

FERMILAB
A Department of Energy National Laboratory

NEWS RELEASE

News Release - March 2, 1995

NEWS MEDIA CONTACTS:
Judy Jackson, 708/840-4112 (Fermilab)
Gary Pitchford, 708/252-2013 (Department of Energy)
Jeff Sherwood, 202/586-5806 (Department of Energy)

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Batavia, IL 60510
630-840-3351
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PHYSICISTS DISCOVER TOP QUARK

Batavia, IL--Physicists at the Department of Energy's Fermi National Accelerator Laboratory today (March 2) announced the discovery of the subatomic particle called the top quark, the last undiscovered quark of the six predicted by current scientific theory. Scientists worldwide had sought the top quark since the discovery of the bottom quark at Fermilab in 1977. The discovery provides strong support for the quark theory of the structure of matter.

Two research papers, submitted on Friday, February 24, to Physical Review Letters by the CDF and DZero experiment collaborations respectively, describe the observation of top quarks produced in high-energy collisions between protons and antiprotons, their antimatter counterparts. The two experiments operate simultaneously using particle beams from Fermilab's Tevatron, world's highest energy particle accelerator. The collaborations, each with about 450 members, presented their results at seminars held at Fermilab on March 2.

"Last April, CDF announced the first direct experimental evidence for the top quark," said William Carithers, Jr., cospokesman, with Giorgio Bellettini, for the CDF experiment, "but at that time we stopped short of claiming a discovery. Now, the analysis of about three times as much data confirms our previous evidence and establishes the discovery of the top quark."

The DZero collaboration has discovered the top quark in an independent investigation. "The DZero observation of the top quark depends primarily on the number of events we have seen, but also on their characteristics," said Paul Grannis, who serves, with Hugh Montgomery, as DZero cospokesman. "Last year, we just did not have enough events to make a statement about the top quark's existence, but now, with a larger data sample, the signal is clear."

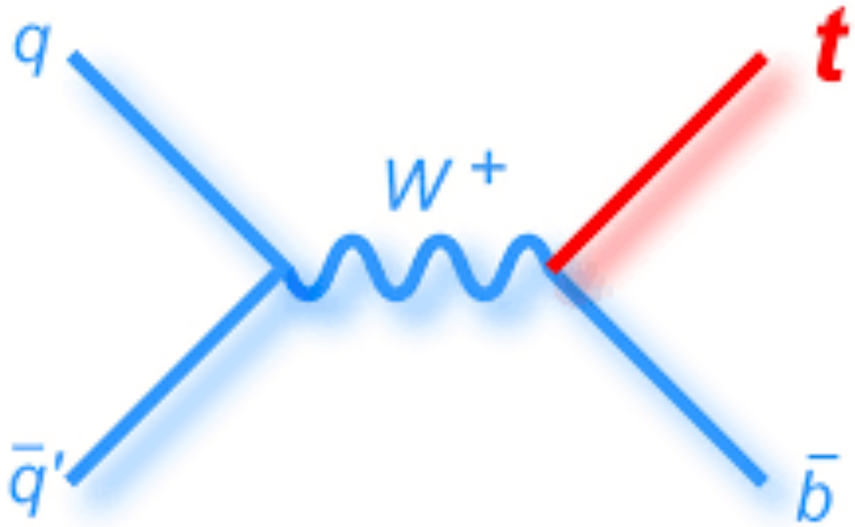
Physicists identify top quarks by the characteristic electronic signals they produce. However, other phenomena can sometimes mimic top quark signals. To claim a discovery, experimenters must observe enough top quark events to rule out any other source of the signals.

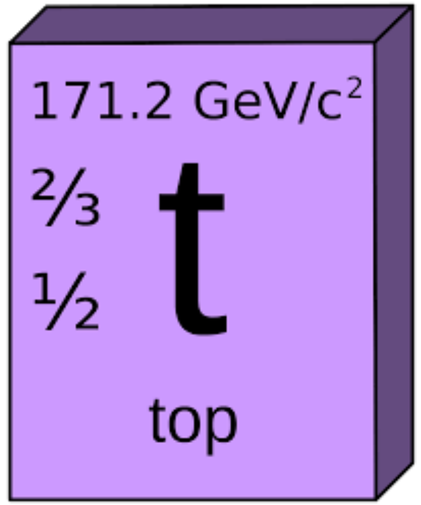
"This discovery serves as a powerful validation of federal support for science," said Secretary of Energy Hazel R. O'Leary. "Using one of the world's most powerful research tools, scientists at Fermilab have made yet another major contribution to human understanding of the fundamentals of the universe."

The Department of Energy, the primary steward of U.S. high-energy physics, provided the majority of funding for the research. The Italian Institute for Nuclear Physics and the Japanese Ministry of Education, Science and Culture made major contributions to CDF. Support for DZero came from Russia, France, India, and Brazil. The National Science Foundation contributed to both collaborations. Collaborators include scientists from Brazil, Canada, Colombia, France, India, Italy, Japan, Korea, Mexico, Poland, Russia, Taiwan, and the U.S.

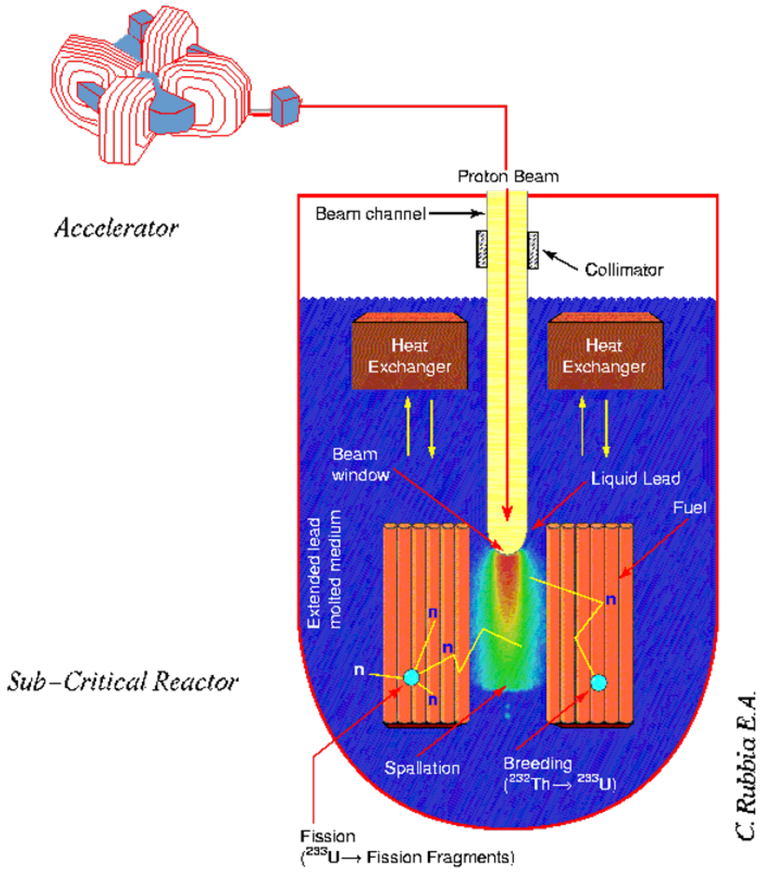
"The discovery of the top quark is a great achievement for the collaborations," said Fermilab Director John Peoples, "and also for the men and women of Fermilab who imagined, then built, and now operate the Tevatron accelerator. We have much to learn about the top quark, and more of nature's best-kept secrets to explore. We look forward to beginning a new era of research with the Tevatron, making the best use of the world's highest-energy collider."

Fermilab, 30 miles west of Chicago, is a high-energy physics laboratory operated by Universities Research Association, Inc. under contract with the U.S. Department of Energy.



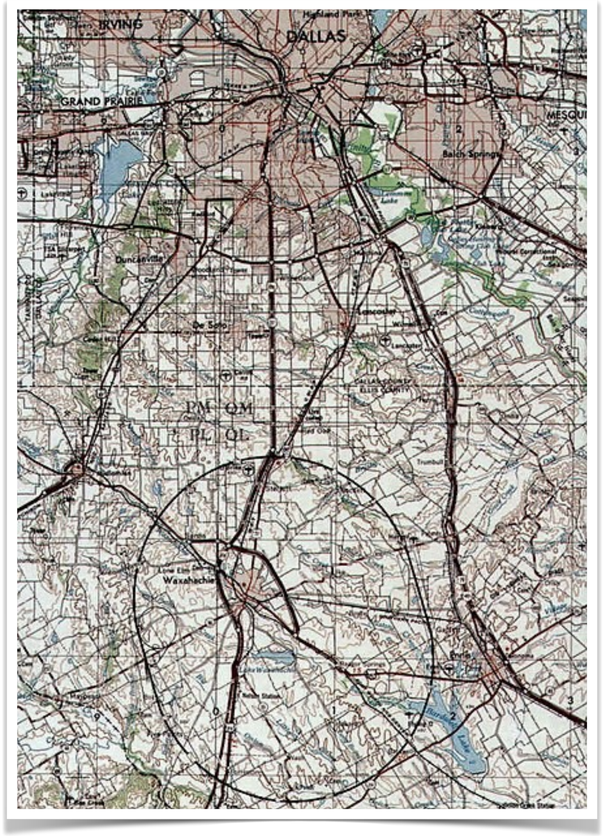


1997: Accelerator Driven Systems



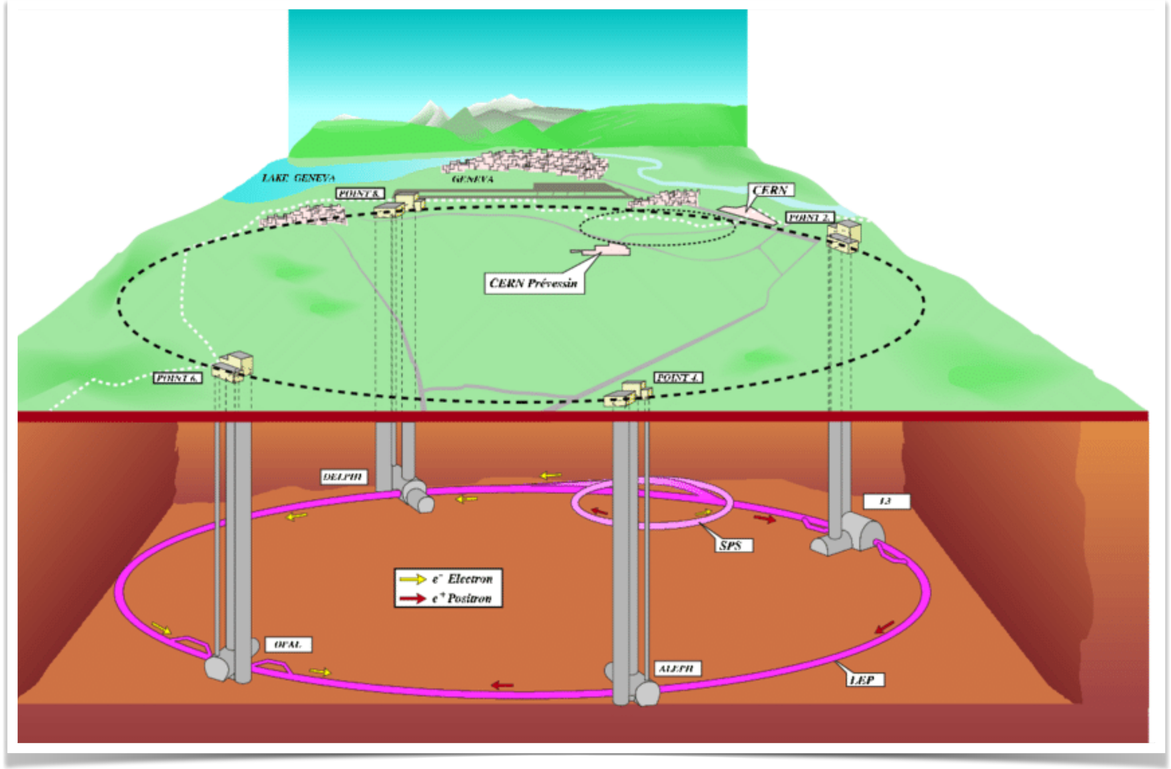
“Energy Amplifier”
Proposal of Carlo Rubbia

1993: US cancels the SSC project



1994: CERN Council approves the LHC.. SSC was gone, but it shaped the LHC. CERN embraces US, Japan and others… LHC became a global project

2000: The end of LEP



2 November 2000: Steve Myers pulls the plug

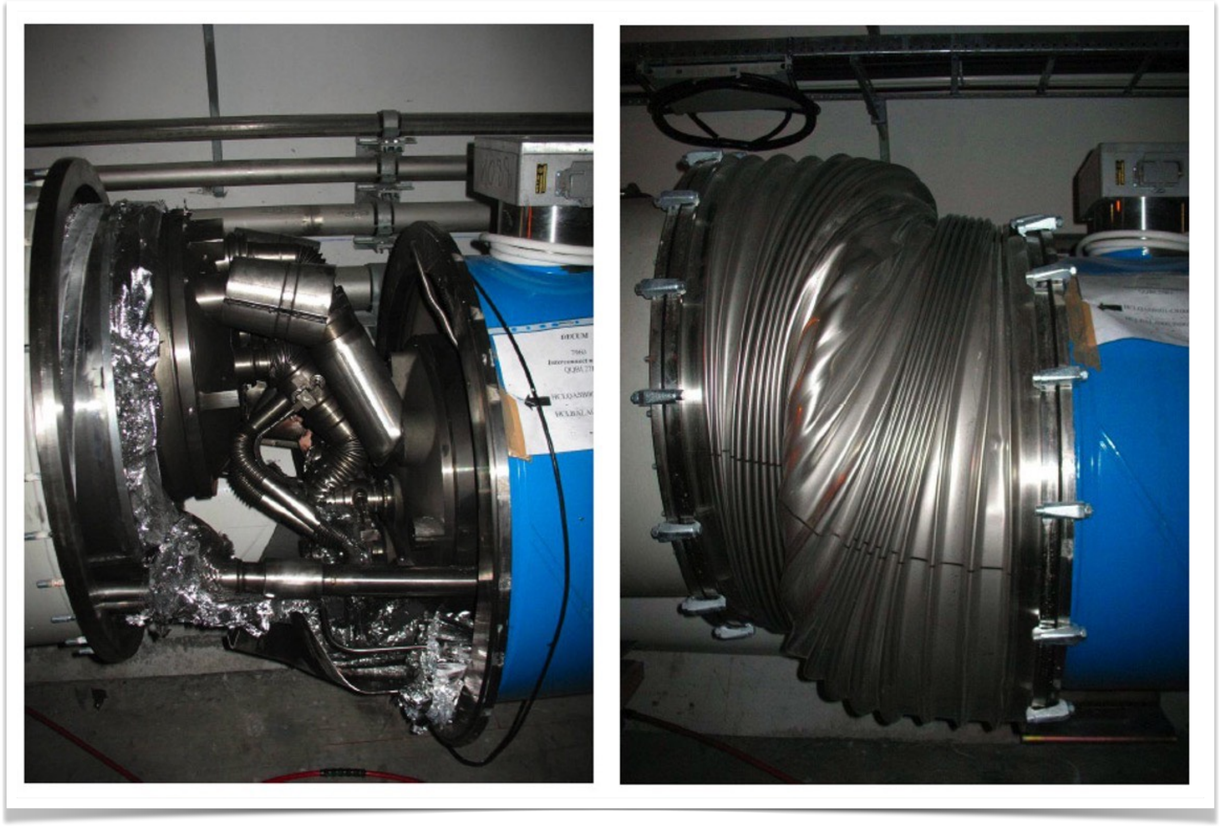
2003: Fear across the planet… are they going to end the world?

Is the new LHC accelerator producing black holes?

2008: LHC - First beam

… and the world continues to exist!

2008: LHC - Breakdown



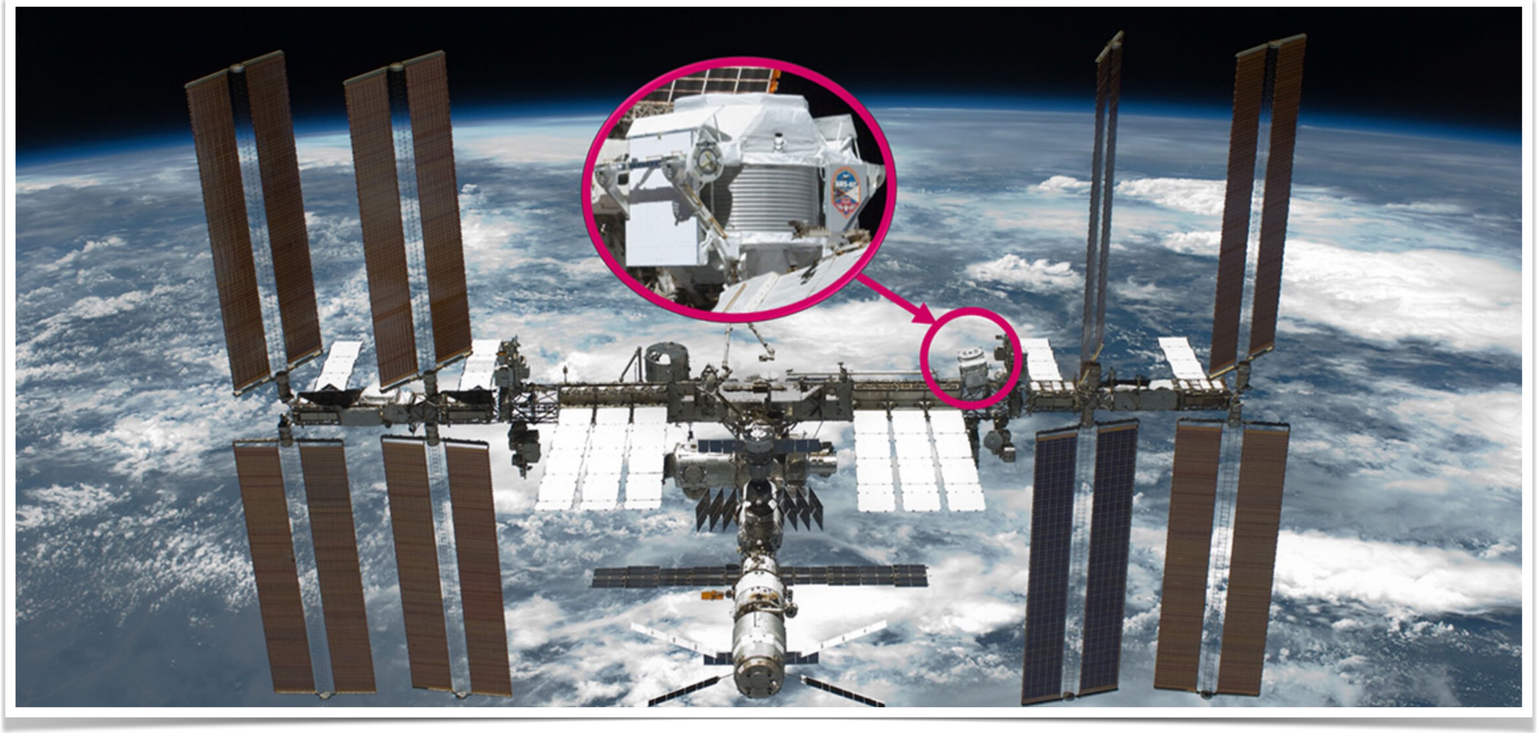
Only a few days later, the LHC broke down:

A helium release due to a electrical short showed the power of expanding gas

2010: The LHC overtakes the Tevatron
High Energy running begins

- LHC starts running at 3.5 TeV per beam
- Soon recording data far faster than the Tevatron

2010: CERN in space

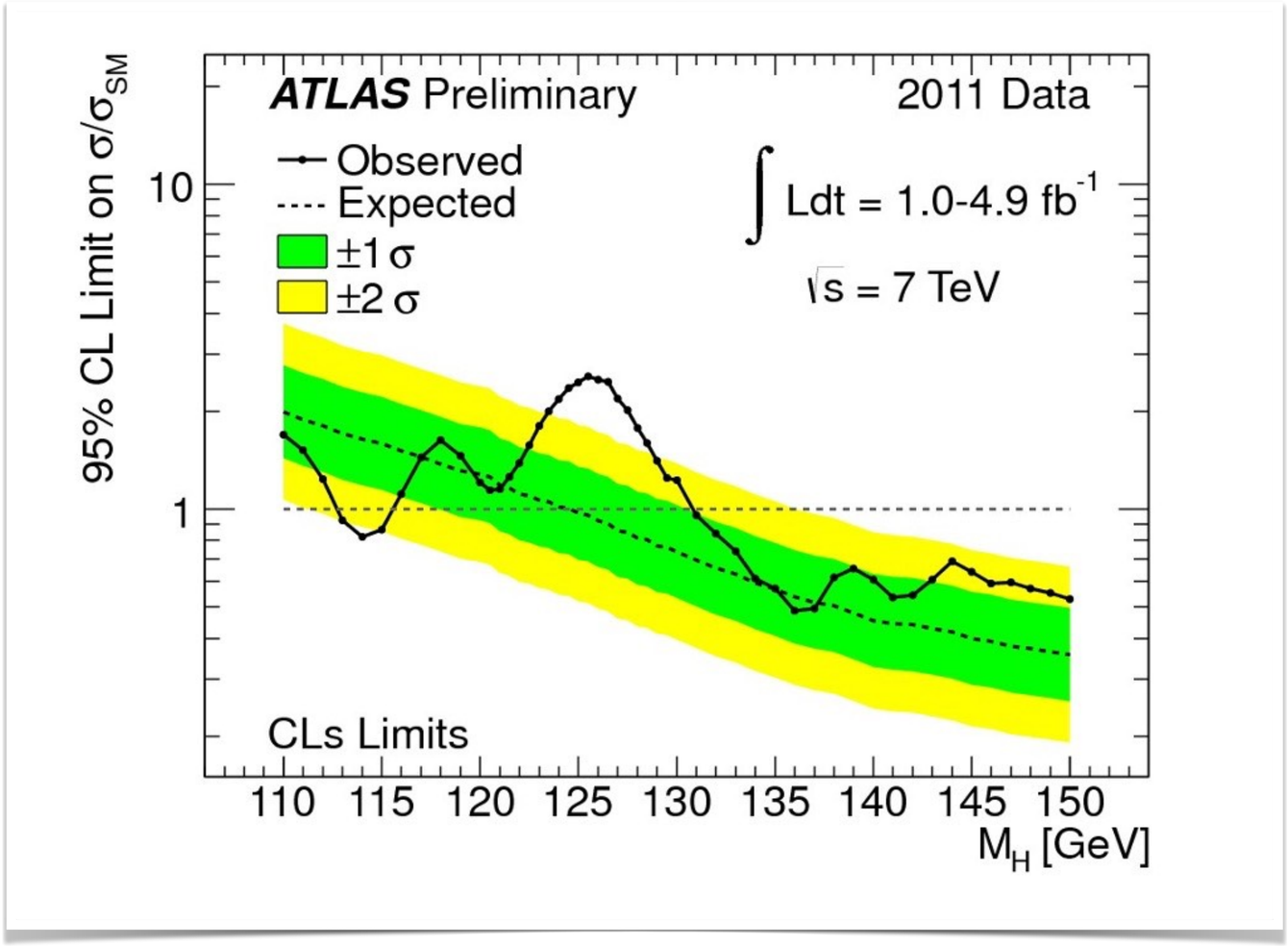


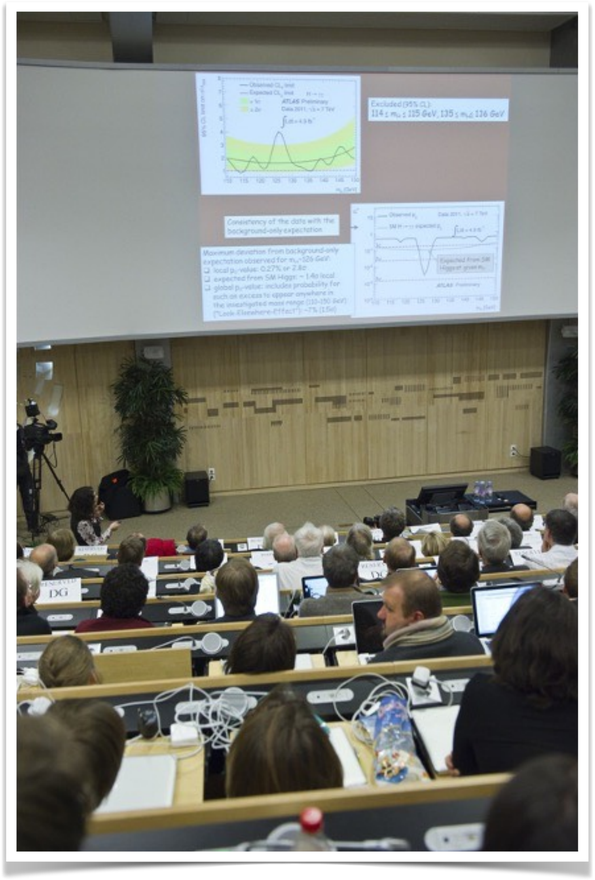
The AMS experiment assembled and operated at CERN is installed at the International Space Station ISS

2011: Opening to the world

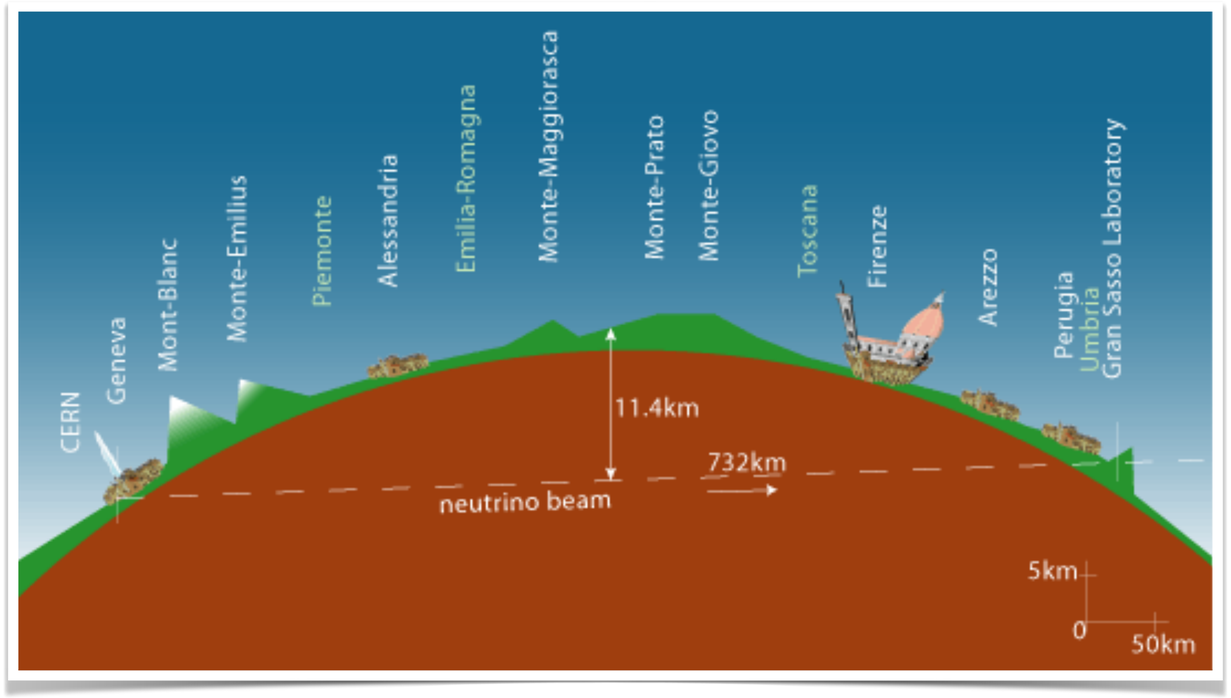
16 September 2011:
First non European country becomes associated member of CERN

2011: Hints of Higgs





2011: particles break speed of light limit: Really?



OPERA experiment in Grand Sasso (Italy) claims that neutrinos from CERN travel with more than speed of light

Well, it was a faulty optical fibre connector

SPEED LIMIT

C

299792 km/s

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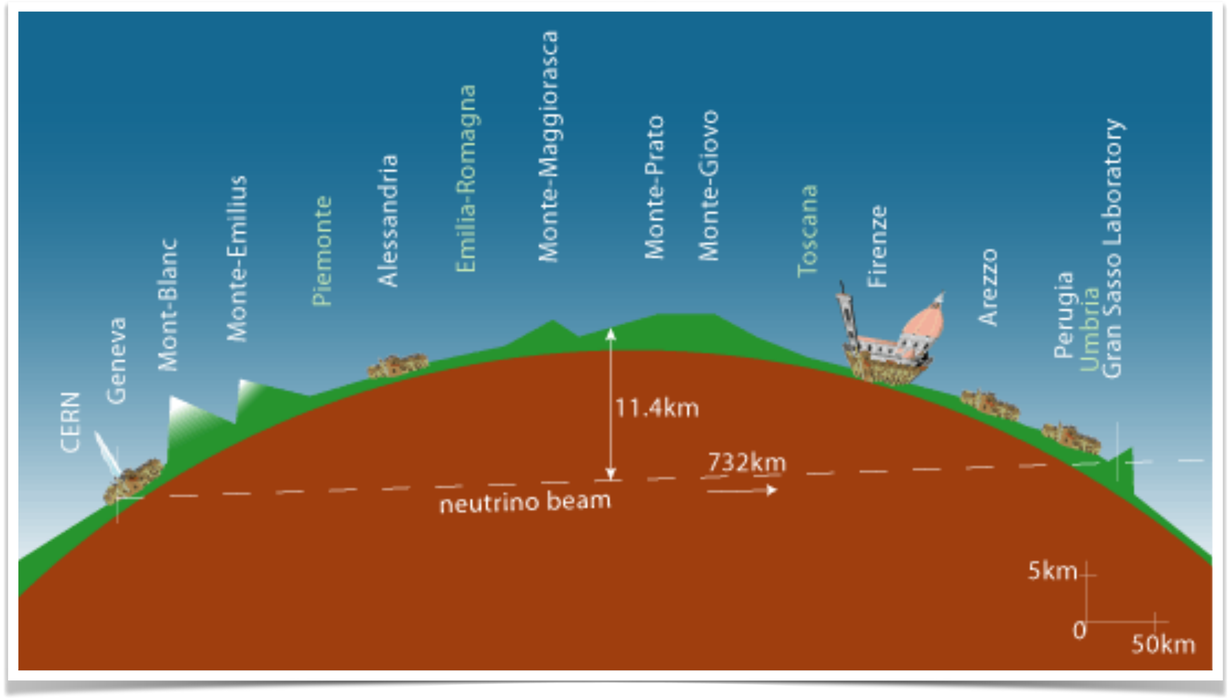

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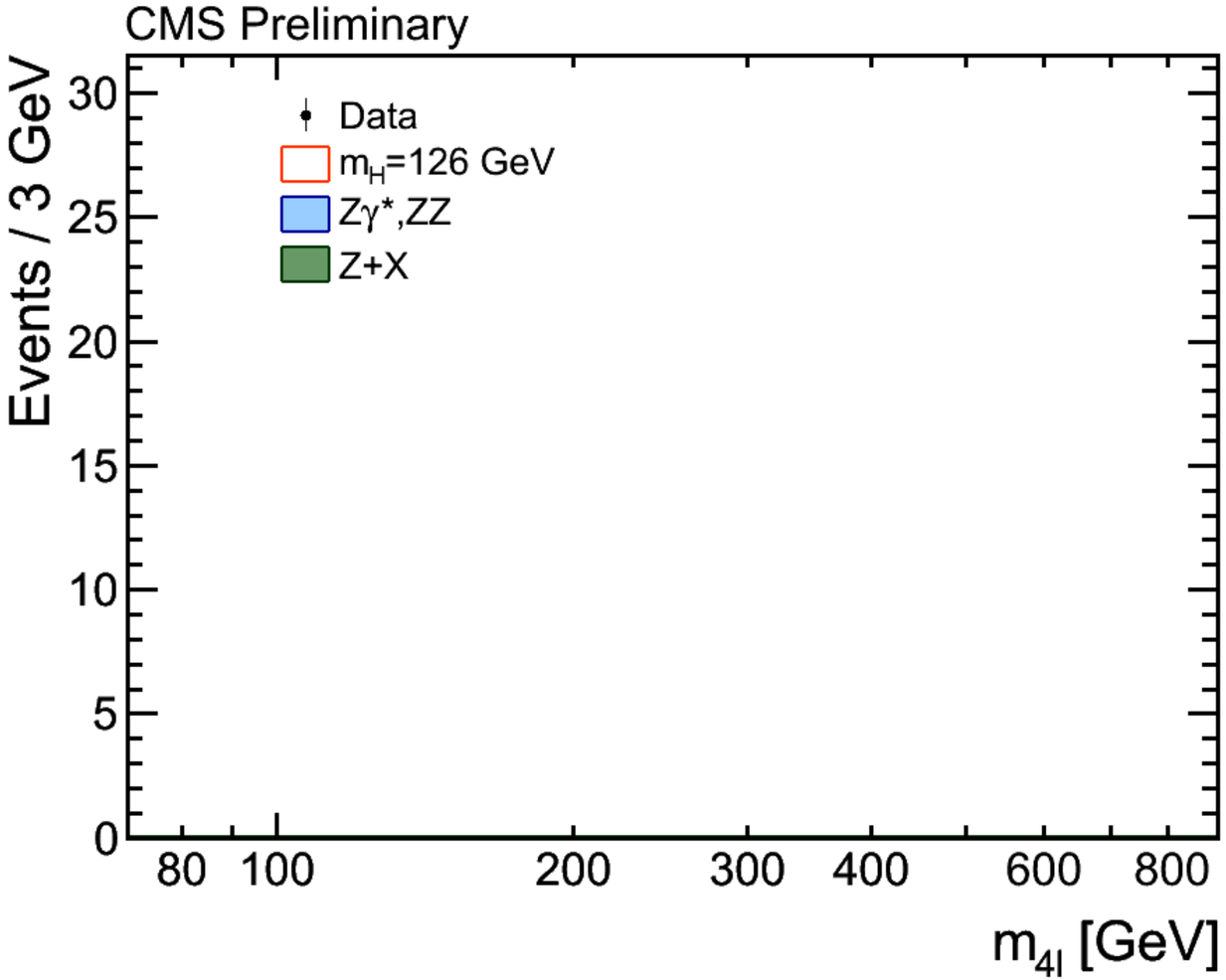
2012: A discovery!

Example from the CMS experiment:

The Higgs-Boson



2012: A discovery!

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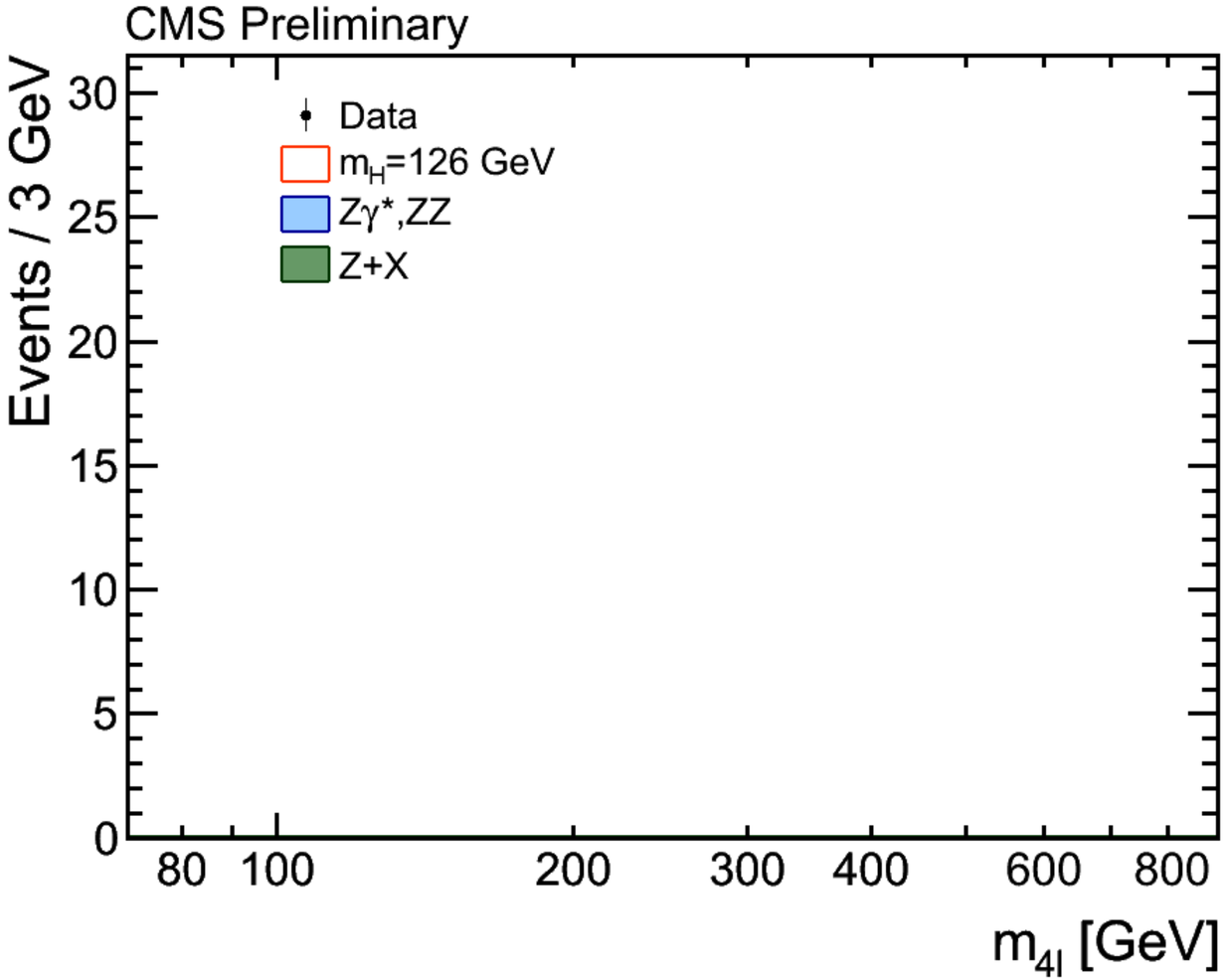

2012: A discoverv!

Example from the CMS experiment:

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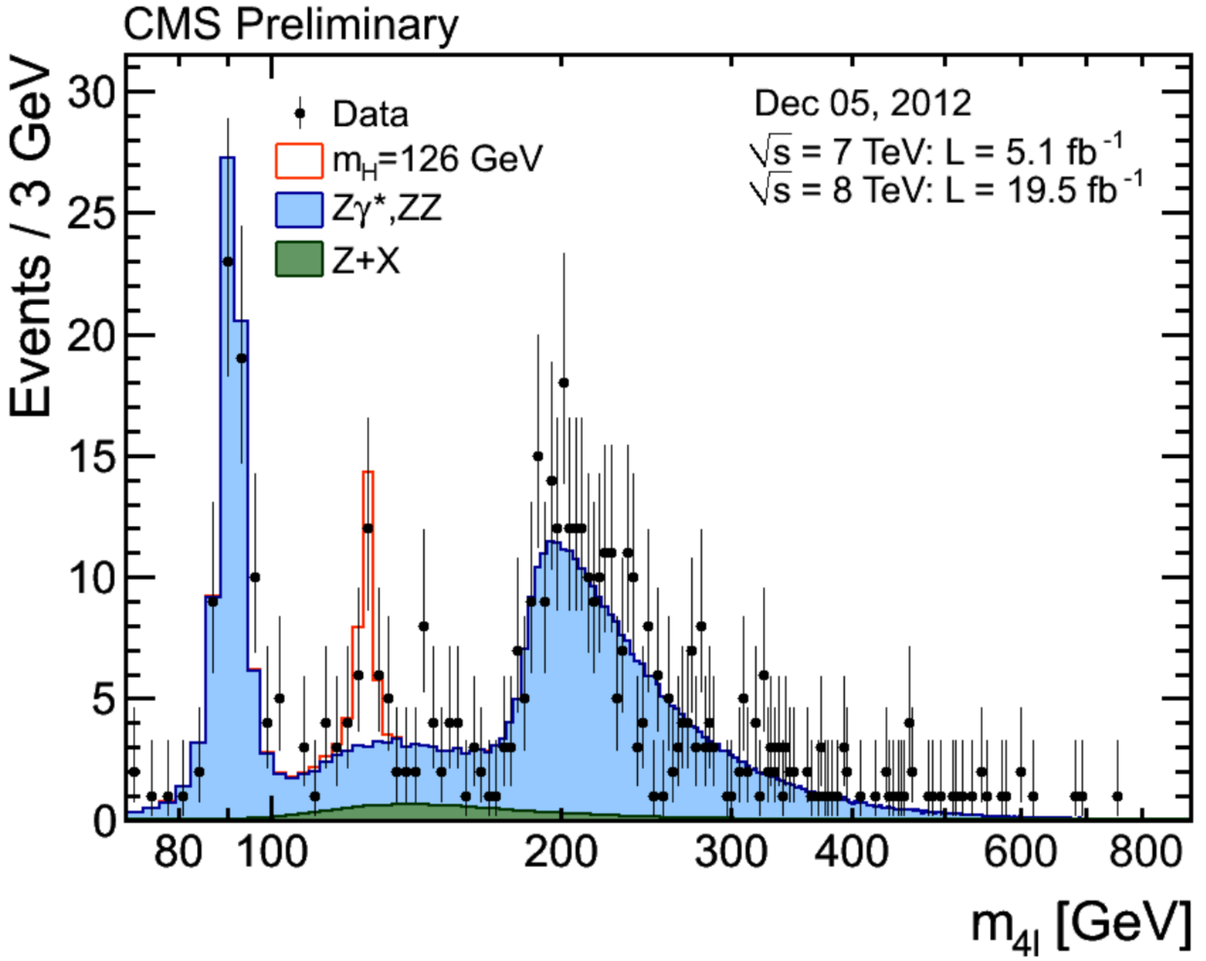


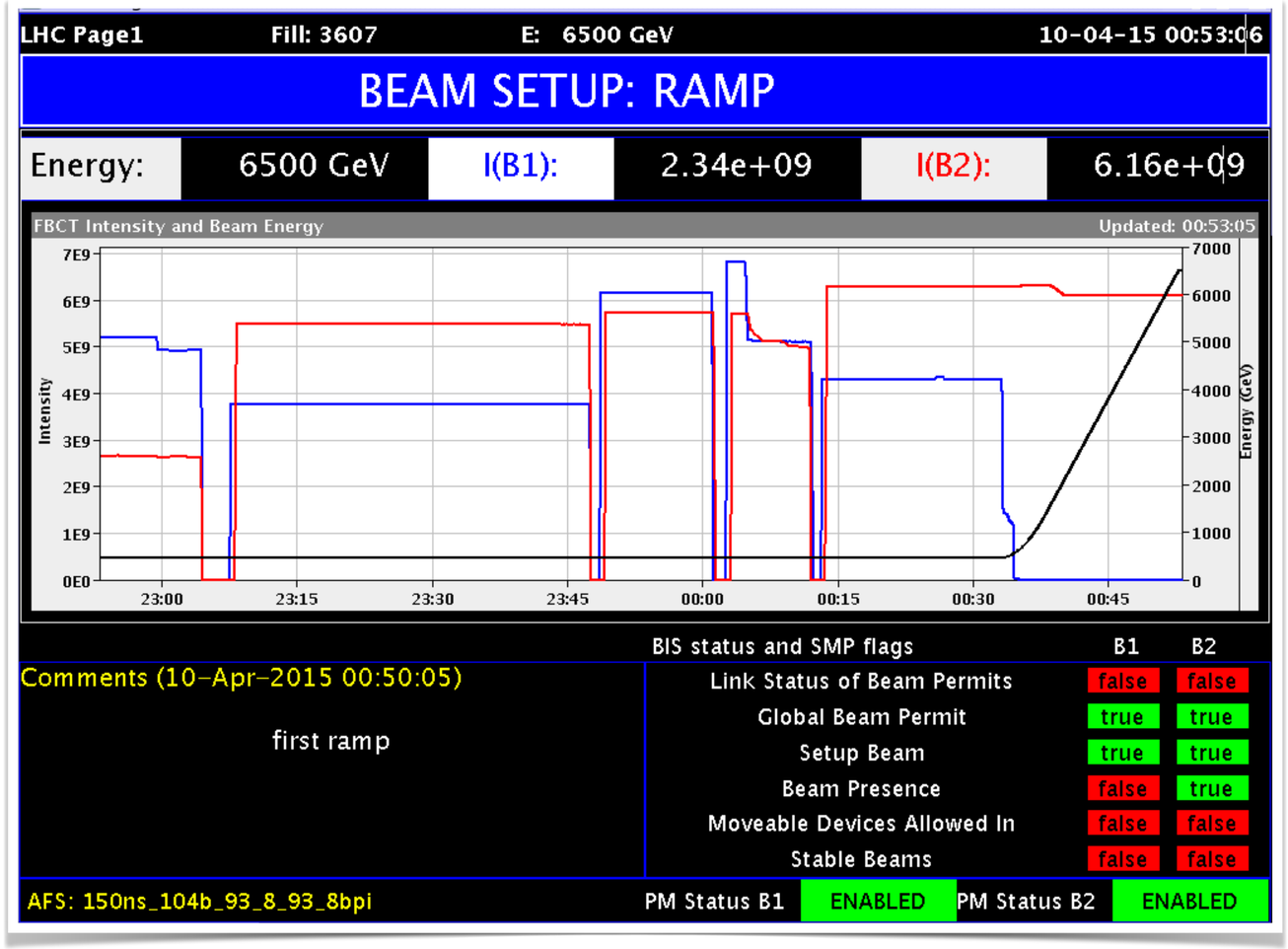
2013: The Nobel Price!

'The Large Hadron Collider at CERN is the largest most complex machine in the world, possibly the universe. By smashing particles together at enormous energies, it recreates the conditions of the Big Bang. The recent discovery of what looks like the "Higgs particle" is a triumph of human endeavour and international collaboration. It will change our perception of the world and has the potential to offer insights into a complete theory of everything.'

Stephen Hawking

2015: Record LHC Energy

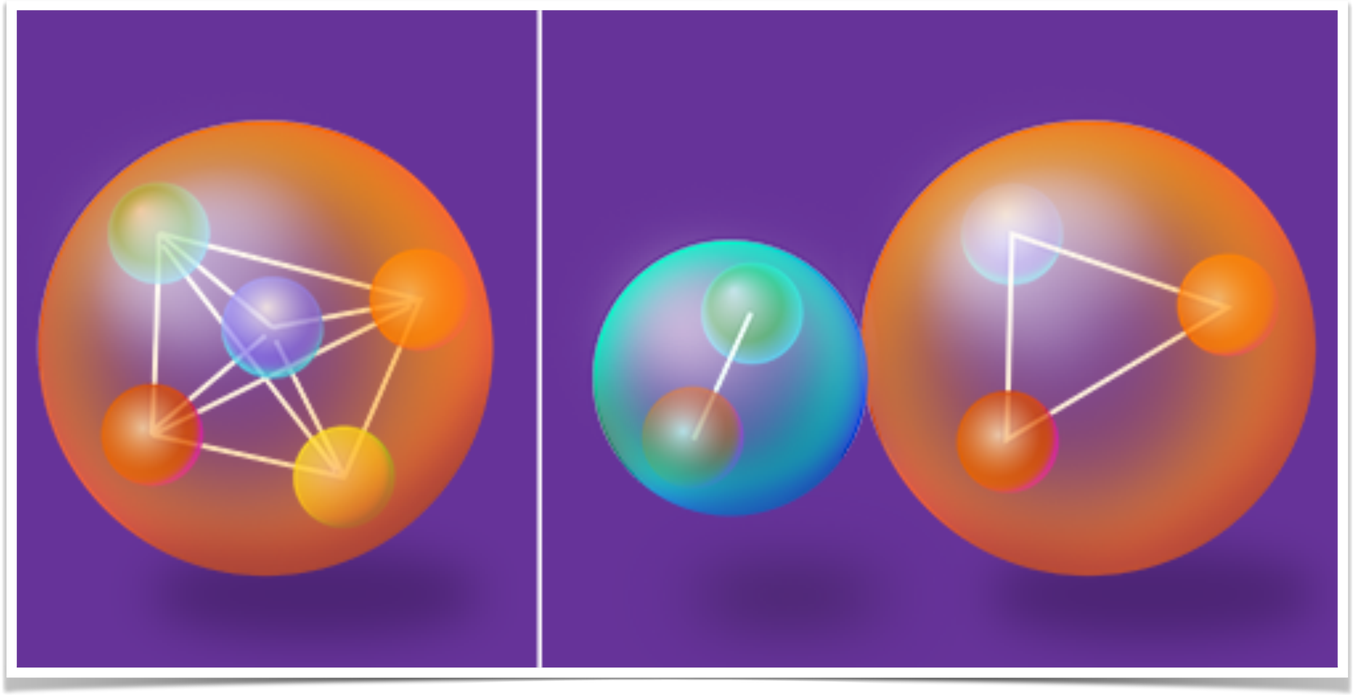
After its first two year long shutdown, the LHV starts Run 2 at a new recored beam energy of 6.5 TeV



2015: The elusive Pentaquark

Pentaquark:

A meson-baryon “molecule”



2018: Building HL-LHC

The civil engineering work for the High Luminosity LHC (HL-LHC) starts

2018: Look at the Swiss bank notes

Switzerlands scientific expertise:

Looks like a particle collision at CERN

2023: Science Gateway Inauguration

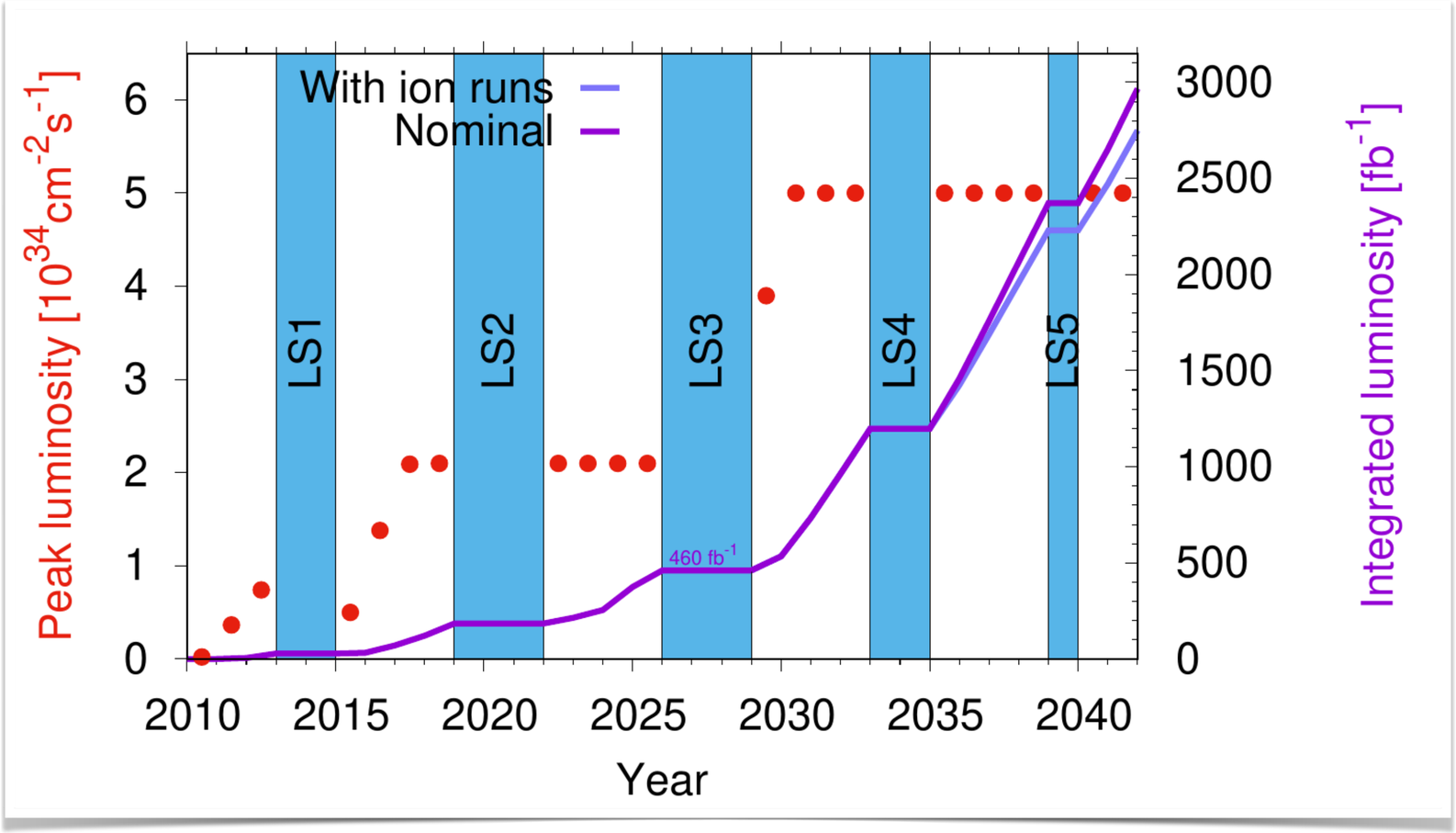
Science Gateway: CERN's flagship eduction and outreach facility

2023: Newton’s anti apple

The ALPHA experiment:
Antimatter interacts with gravity similar to regular matter

CERN repeated Newton’s iconic “apple experiment” with antimatter

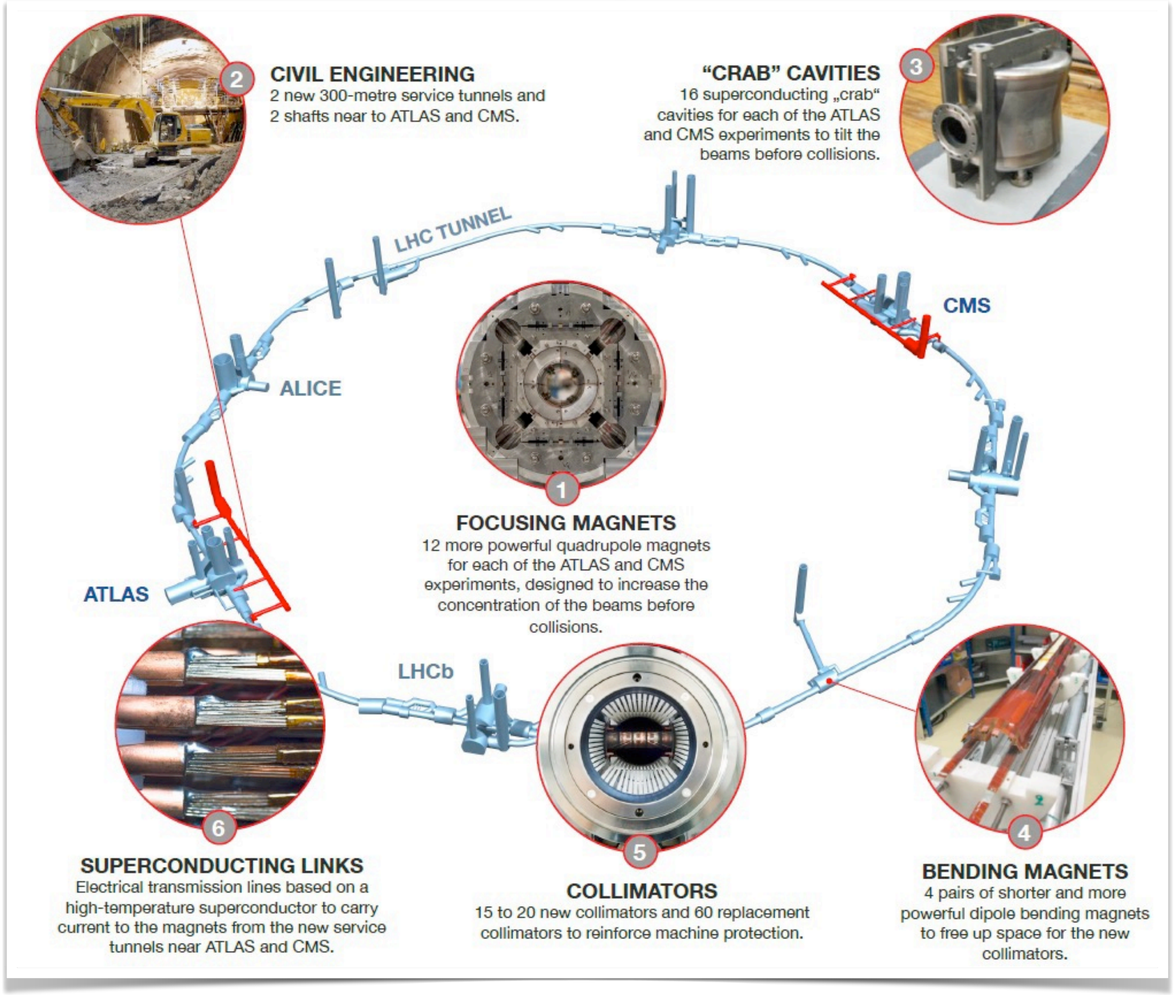
2024: What next?



Prepare for LHC upgrade:
High Luminosity LHC (HL-LHC)

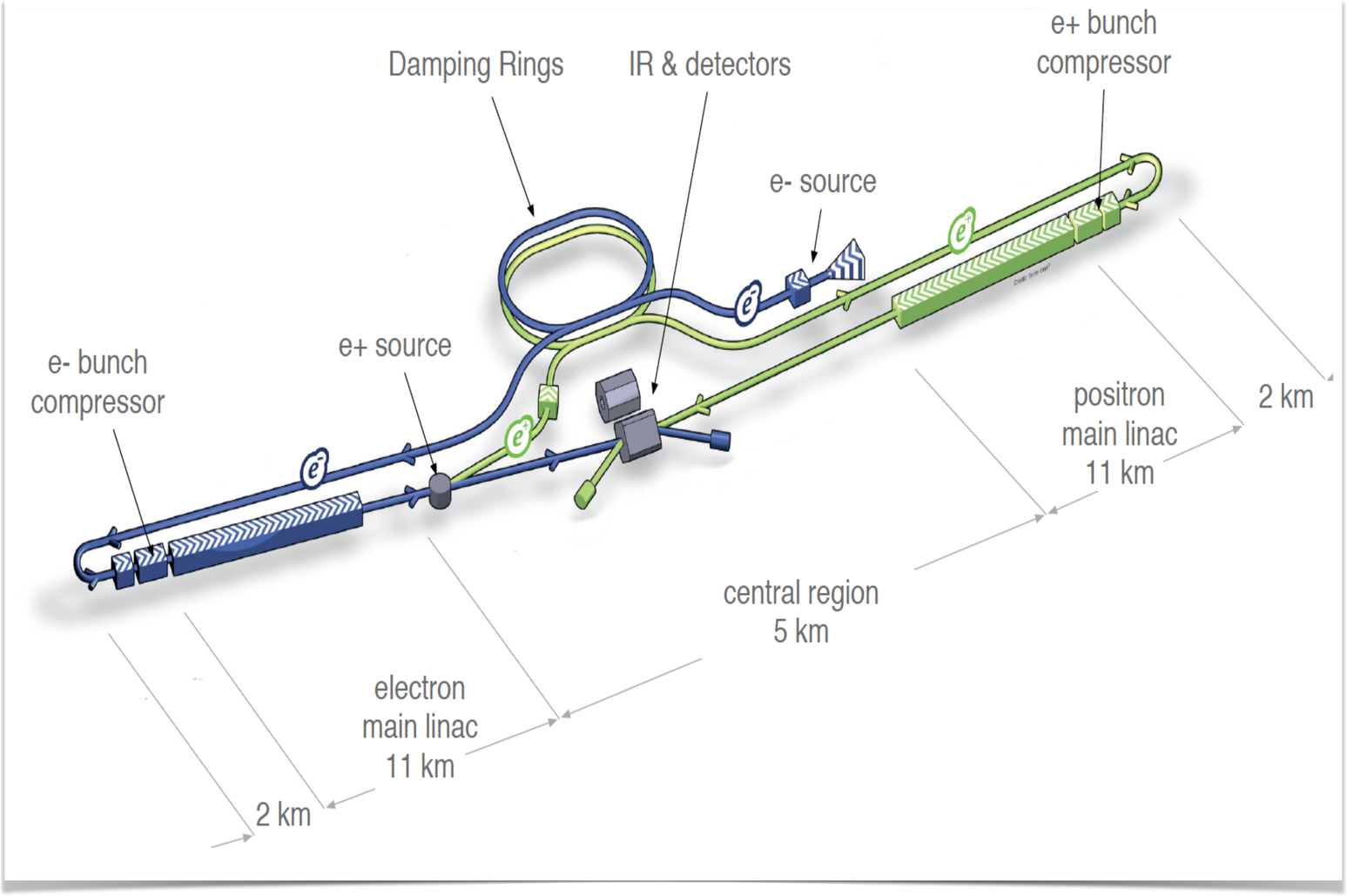
From 2030 to 2040

HL-LHC Project



- New quadrupole magnets near the interaction points
- New 11 Tesla short dipole magnets
- Collimation upgrade
- Crab Cavities
- Accelerator safety upgrade
- Major interventions on 1.2 km of the LHC

International Linear Collider (ILC) Study

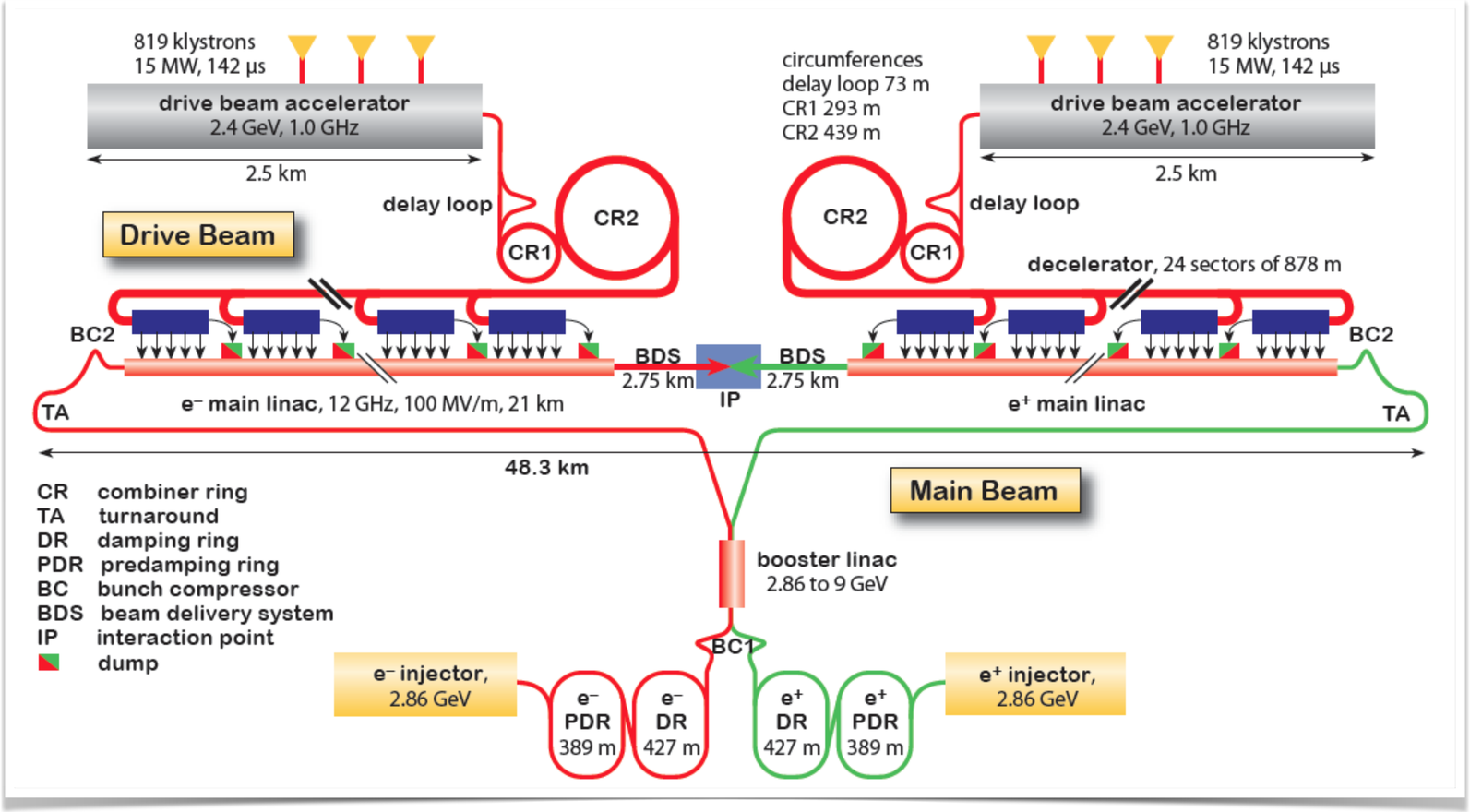


0.5 TeV collision energy, upgradable to 1 TeV

SC RF industry standard

mature design! (TDR in 2012)

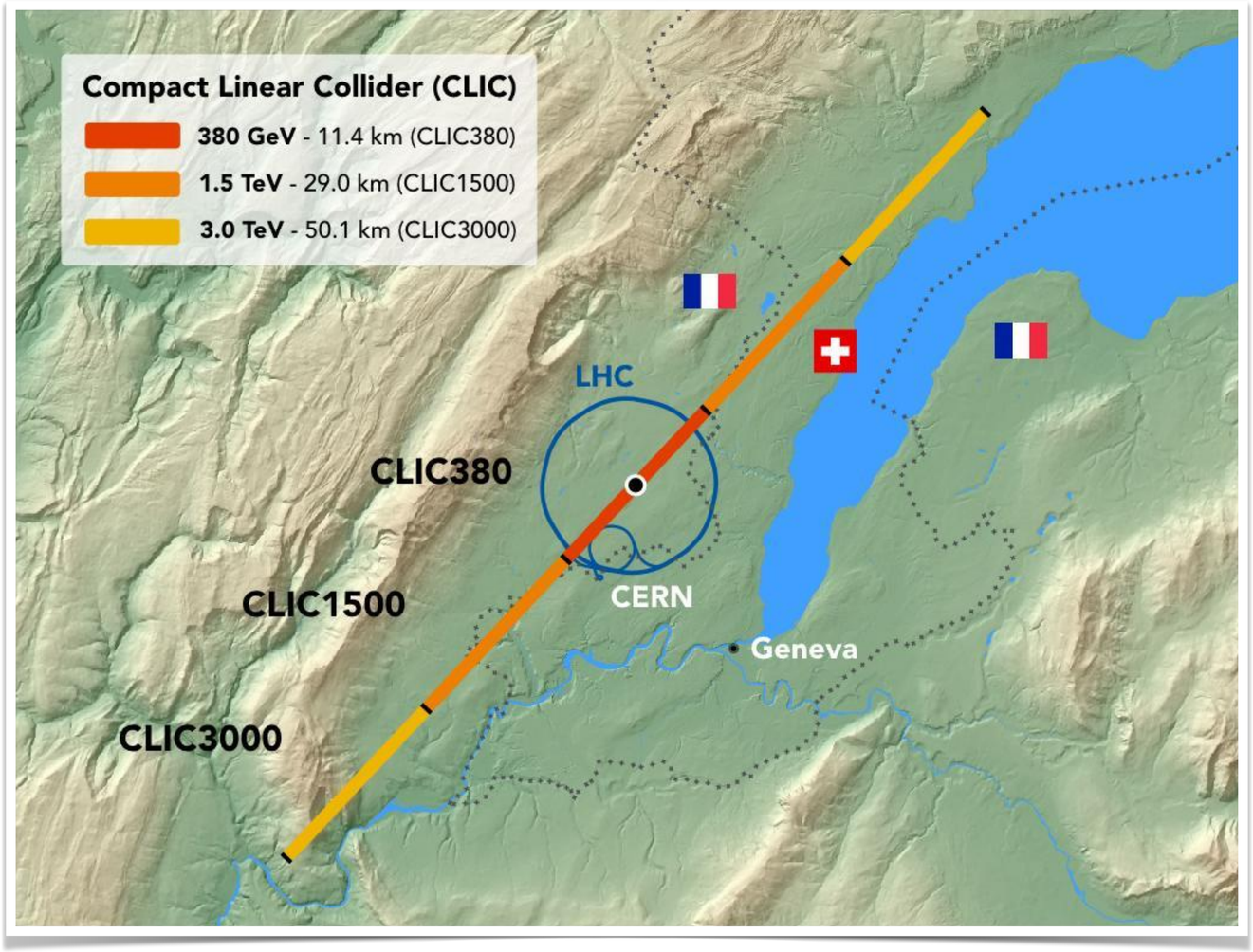
Compact Linear Collider (CLIC) Study



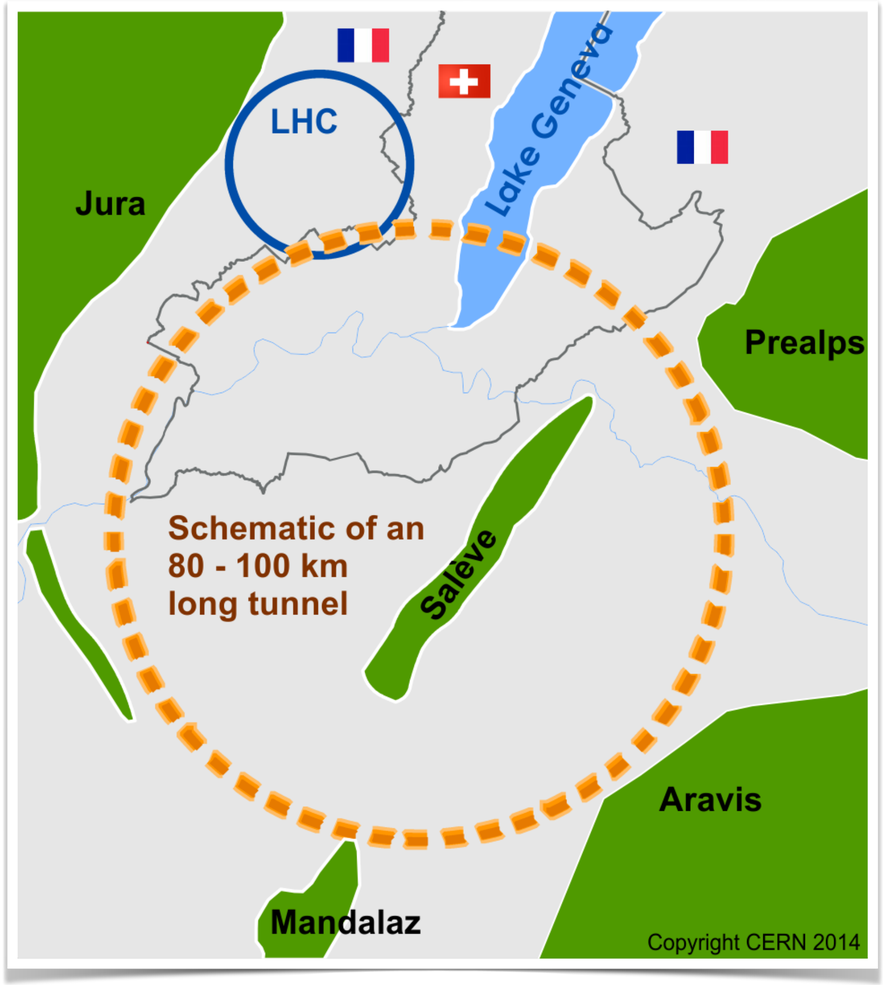
Two-beam scheme,
1-3 TeV collision energy
Option for 380 GeV explored
(top quark pair production)

CTF3 facility – key R&D done
Ready for demonstrator project

Compact Linear Collider (CLIC) Study

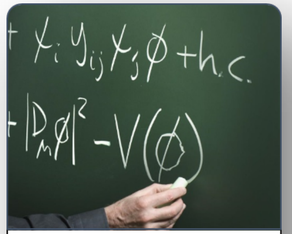


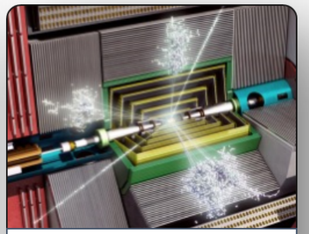
Future Circular Collider (FCC) Study

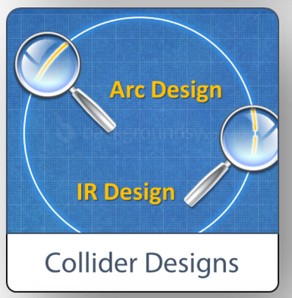


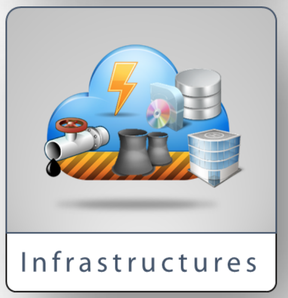
- **International FCC collaboration to study:**
- pp collider *(FCC-hh)*,
  - 16 Tesla magnets,
  - 91 km circumference,

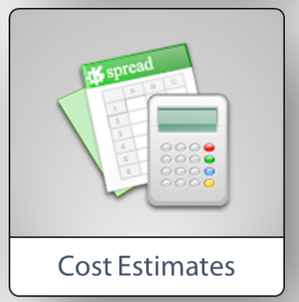
  100 TeV collision energy
- e^+e^- collider *(FCC-ee)*
  potential first step
- pe collider *(FCC-he)*
- **If realised the project could last until 2090!**











Thank You