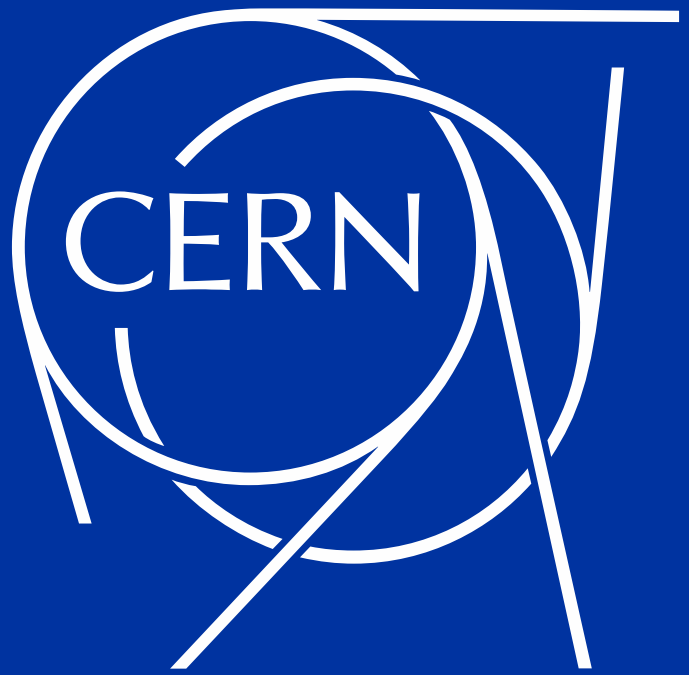
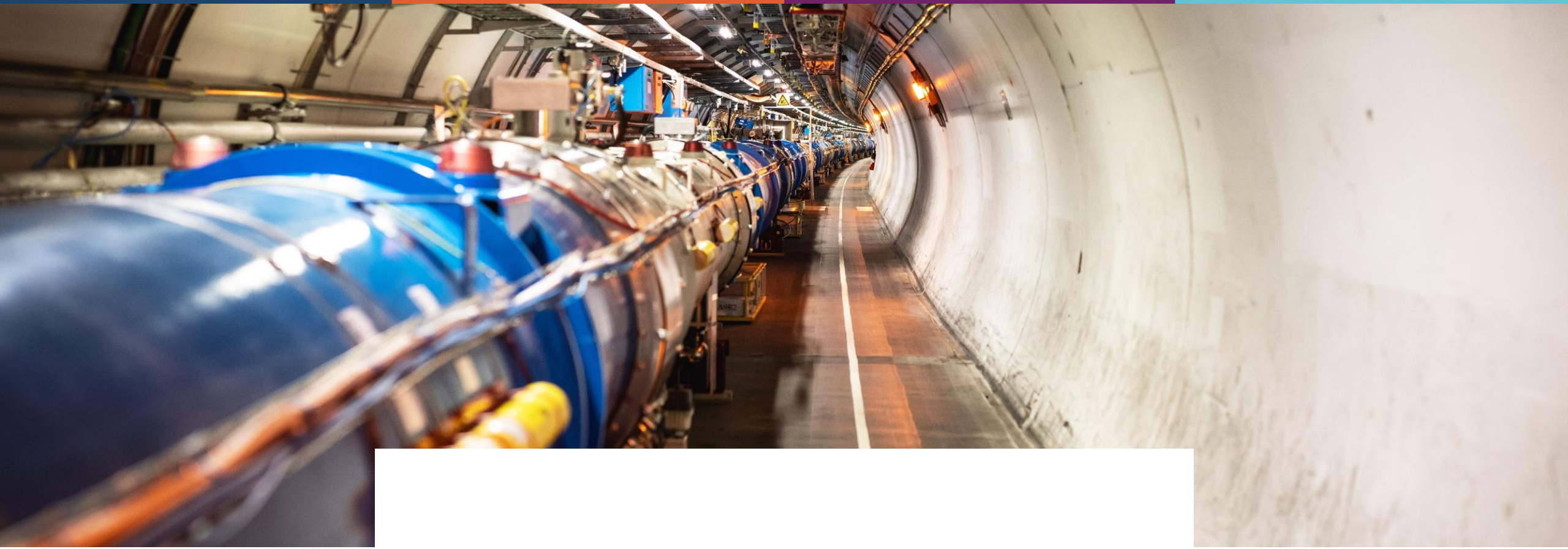

CERN



Velkommen til CERN

Mest om CERN—og litt om Norge og CERN

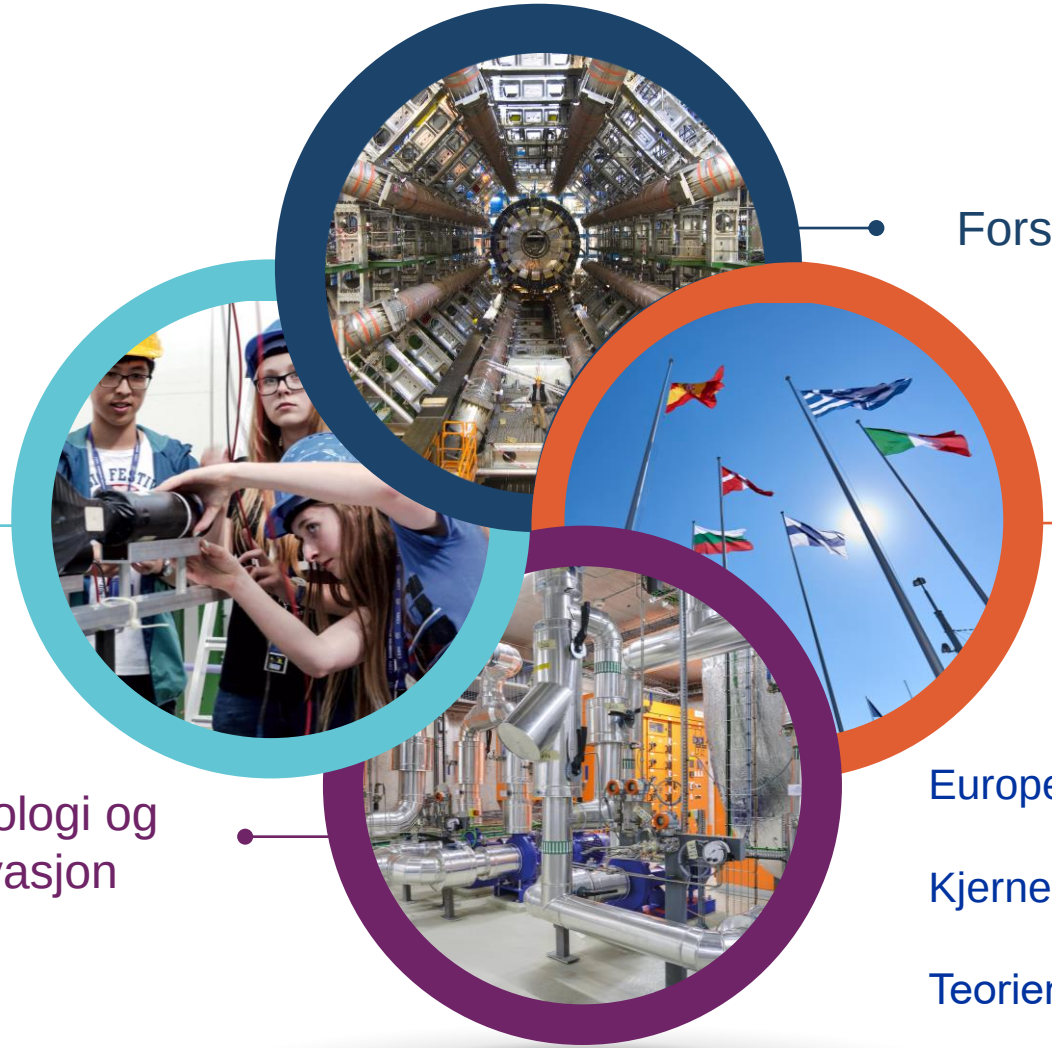
Jens.Vigen@cern.ch, bibliotekar
Summer@CERN, 28 juni 2022

CERN er verdens største laboratorium for partikkelfysikk.

CERNs mål er å studere de mest elementære partiklene i universet og universets lover.

En kort samtale med den store partikkel-popstjernen

CERNs fire grunnpilarer



Forskning

Samarbeid

Opplæring og utdanning

Teknologi og innovasjon

European Organization for Nuclear Research

Kjernefysikk

Teorien om alt …

“The God particle”

På leting etter Higgs

KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Physics for 2013 to **François Englert** and **Peter W. Higgs** "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".

The Nobel Prize 2013 **in Physics**

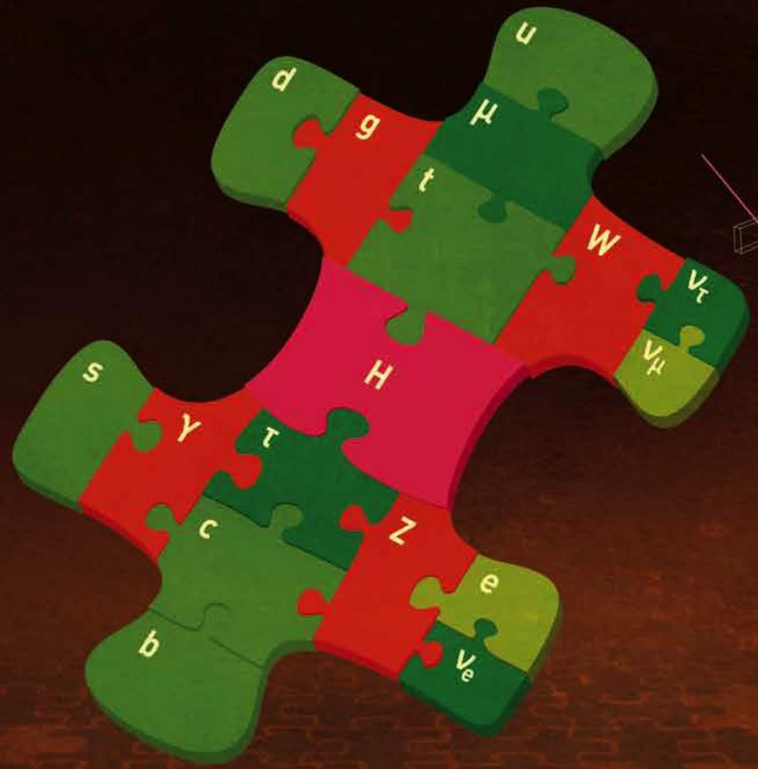
Here, at last!

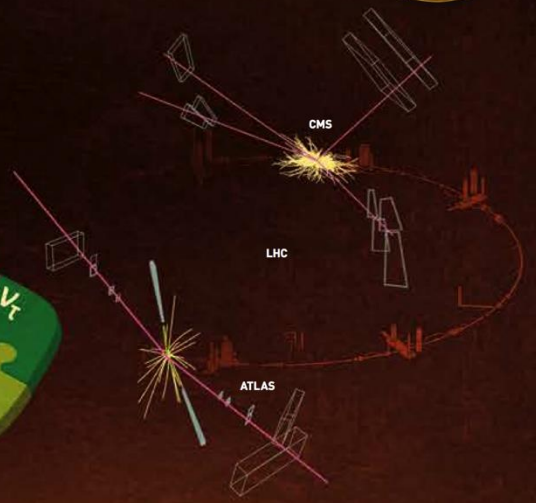
François Englert and Peter W. Higgs are jointly awarded the Nobel Prize in Physics 2013 for the theory of how particles acquire mass. In 1964, they proposed the theory independently of each other (Englert did so together with his now-deceased colleague Robert Brout). In 2012, their ideas were confirmed by the discovery of a so-called Higgs particle, at the CERN laboratory outside Geneva in Switzerland.

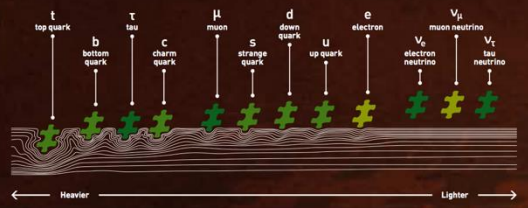
The awarded mechanism is a central part of the Standard Model of particle physics that describes how the world is constructed. According to the Standard Model, everything – from flowers and people to stars and planets – consists of just a few building blocks: *matter particles* which are governed by forces mediated by *force particles*. And the entire Standard Model also rests on the existence of a special kind of particle: *the Higgs particle*.

The Higgs particle is a vibration of an invisible field that fills up all space. Even when our universe seems empty, this field is there. Had it not been there, nothing of what we know would exist because particles acquire mass only in contact with the Higgs field. Englert and Higgs proposed the existence of the field on purely mathematical grounds, and the only way to discover it was to find the Higgs particle.

The Nobel Laureates probably did not imagine that they would get to see the theory confirmed in their lifetimes. To do so required an enormous effort by physicists from all over the world. Almost half a century after the proposal was made, on July 4, 2012, the theoretical prediction could celebrate its biggest triumph, when the discovery of the Higgs particle was announced.







ATLAS
In the collision, a short-lived Higgs particle is created, which decays into two muons (tracks in red) and two electrons (tracks in green).

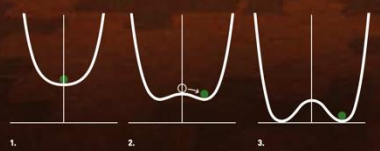
CMS
A short-lived Higgs particle is created in the collision and decays into four muons (tracks in red).

The Particle Collider LHC
Protons – hydrogen nuclei – travel at almost the speed of light in opposite directions inside the circular tunnel, 27 kilometres long. The LHC (Large Hadron Collider) is the largest and most complex machine ever constructed by humans. In order to find a trace of the Higgs particle, two huge detectors, ATLAS and CMS, are capable of seeing the protons collide over and over again, 40 million times a second.

↑
The Field
Matter particles acquire mass in contact with the invisible field that fills the whole universe. Particles that are not affected by the Higgs field do not acquire mass, those that interact weakly become light, and those that interact strongly become heavy. For example, electrons acquire mass from the field, and if it suddenly disappeared, all matter would collapse as the suddenly massless electrons dispersed at the speed of light. The weak force carriers, W and Z particles, get their masses directly through the Higgs mechanism, while the origin of the neutrino masses still remains unclear.

→
Broken Symmetry
The Higgs mechanism relies on the concept of spontaneous symmetry breaking. Our universe was probably born symmetrical (1), with a zero value for the Higgs field in the lowest energy state – the vacuum. But less than one billionth of a second after the Big Bang, the symmetry was broken spontaneously as the lowest energy state moved away (2) from the symmetrical zero-point. Since then, the value of the Higgs field in the vacuum state has been non-zero (3).

Potential energy of the Higgs field



The Puzzle
The Higgs particle (H) was the last missing piece in the Standard Model puzzle. But the Standard Model is not the final piece in the cosmic puzzle. One of the reasons for this is that the Standard Model only describes visible matter, accounting for one sixth of all matter in the universe. To find the rest – the mysterious so-called dark matter – is one of the reasons why scientists continue to chase unknown particles at CERN.

← ←
François Englert
Belgian citizen. Born 1932 in Etterbeek, Belgium. Professor emeritus at Université Libre de Bruxelles, Brussels, Belgium.

←
Peter W. Higgs
British citizen. Born 1929 in Newcastle upon Tyne, United Kingdom. Professor emeritus at University of Edinburgh, United Kingdom.

Private portrait of François Englert: Jean Dominique Burton; portrait of Peter Higgs: Calum Bennetts.

FURTHER READING! More information on the Nobel Prize in Physics 2013: http://kva.se/nobelprizephysics2013 and http://nobelprize.org **REVIEW ARTICLES:** ● **Rose, J.** (2013) *I mårkret bortom Higgs*, Forskning & Framsteg, nr 6 (Swedish). ● **Llewellyn-Smith, C.** (2000) *The Large Hadron Collider*, Scientific American, July. ● **Weinberg, S.** (1999) *A Unified Physics by 2050?*, Scientific American, December. **BOOKS:** ● **Randall, L.** (2013) *Higgs Discovery: The Power of Empty Space*, Bodley Head. ● **Sample, I.** (2013) *Massive: The Higgs Boson and the Greatest Hunt in Science*, Virgin Books. ● **Carroll, S.** (2012) *The Particle at the End of the Universe*, Dutton. ● **Close, F.** (2011) *The Infinity Puzzle*, Oxford University Press. ● **Wilczek, F.** (2008) *The Lightness of Being: Mass, Ether, and the Unification of Forces*, Basic Books. **LINKS:** ● **Link TV** (2012) *CERN Scientists Announce Higgs Boson: The Moment*: http://www.youtube.com/watch?v=DOuyLD9HFNI. ● **CERN** (2010) *CERN LHC Brochure*: http://cds.cern.ch/record/1278169?ln=en ● **Cham, J.** (2012) *The Higgs Boson Explained*. (animation): http://www.phdcomics.com/comics/archive.php?comicid=1489 ● **Higgs, Peter W.** (2010) *My Life as a Boson*. (transcribed speech): http://www.kcl.ac.uk/nms/depts/physics/news/events/MyLifeasaBoson.pdf ● **More references can be found in the Scientific Background:** http://kva.se/nobelprizephysics2013

Editors: Lars Bergström, Lars Brink and Olga Botner, The Nobel Committee for Physics, The Royal Swedish Academy of Sciences; Sara Strandberg and Oscar Stål, Stockholm University; Joanna Rose, Science Writer; Victoria Henriksson, Editor and Linnéa Wallgren, Nobel Assistant, The Royal Swedish Academy of Sciences. **Graphic design:** Ritator **Illustrations:** Johan Jarnestad/ Swedish Graphics **Print:** Åtta45

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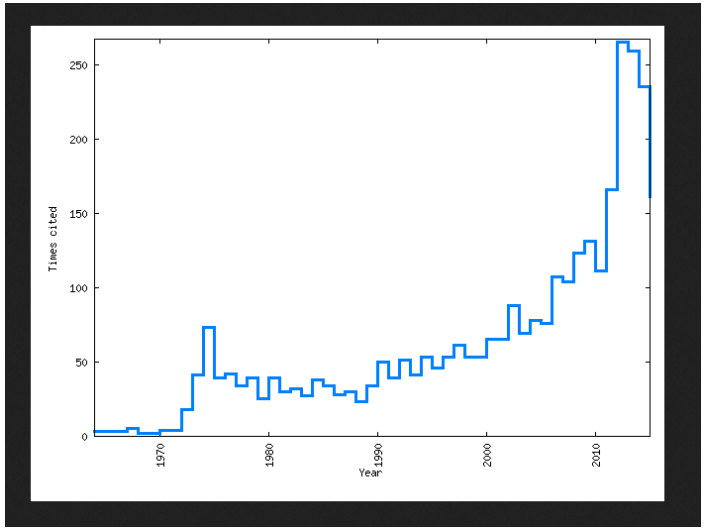
BROKEN SYMMETRIES, MASSLESS PARTICLES AND GAUGE FIELDS

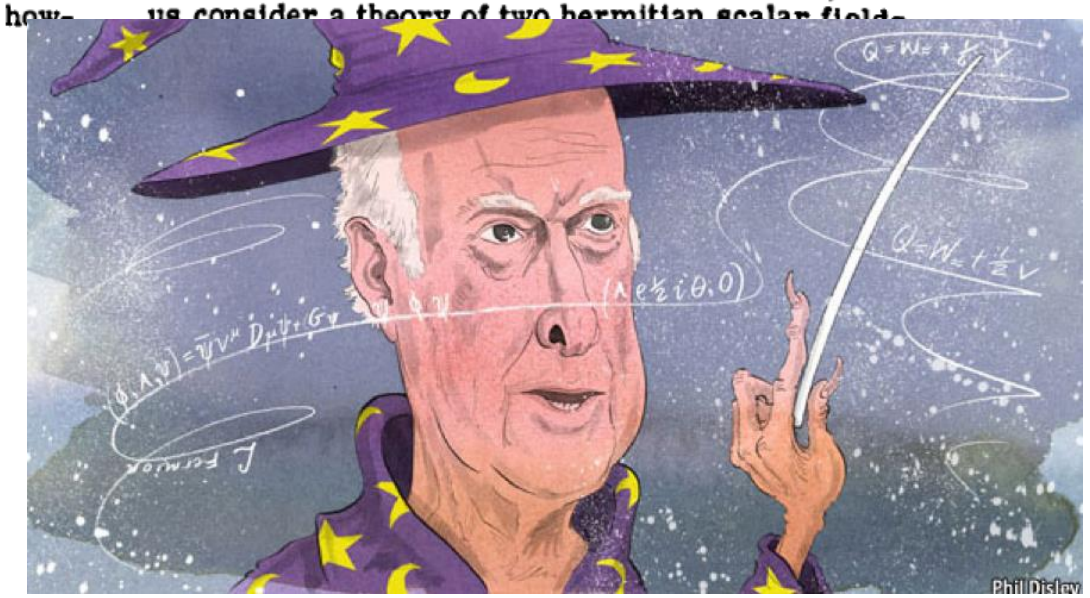
P. W. HIGGS
Tait Institute of Mathematical Physics, University of Edinburgh, Scotland

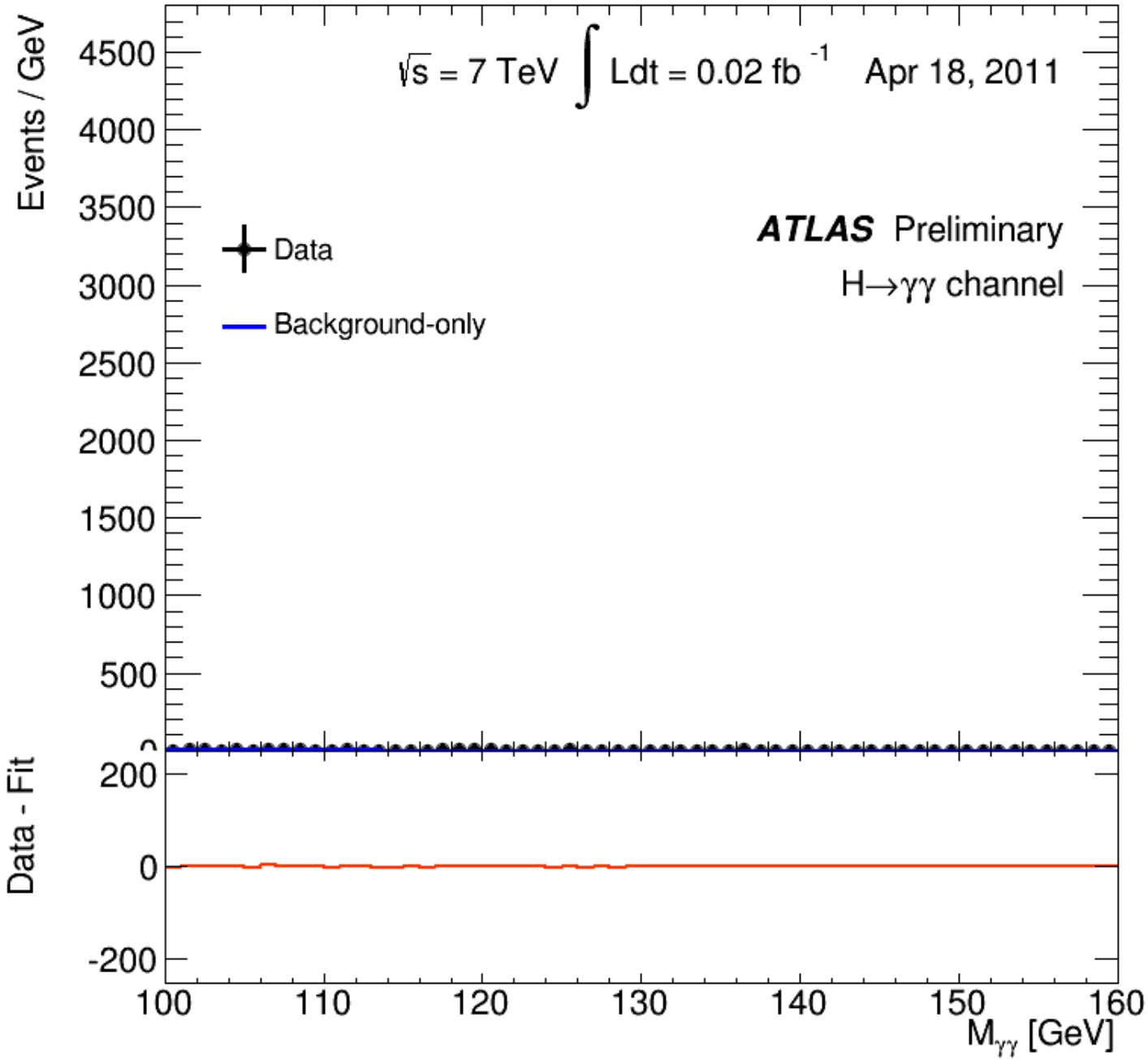
Received 27 July 1964

Recently a number of people have discussed the Goldstone theorem [1,2]: that any solution of a Lorentz-invariant theory which violates an internal symmetry operation of that theory must contain a massless scalar particle. Klein and Lee [3] showed that this theorem does not necessarily apply in non-relativistic theories and implied that their considerations would apply equally well to Lorentz-invariant field theories. Gilbert [4], however, gave a proof that the failure of the Goldstone theorem in the nonrelativistic case is of a type which cannot exist when Lorentz invariance is imposed on a theory. The purpose of this note is to show that Gilbert's argument fails for an important class of field theories, that in which the conserved currents are coupled to gauge fields.

Following the procedure used by Gilbert [4], let us consider a theory of two hermitian scalar fields






√s = 7 TeV ∫ Ldt = 0.02 fb -1 Apr 18, 2011
ATLAS Preliminary
H→γγ channel
Data
Background-only
Events / GeV
4500
4000
3500
3000
2500
2000
1500
1000
500
Data - Fit
200
0
-200
100
110
120
130
140
150
160
Mγγ [GeV]

Physics Letters B

Available online 17 August 2012

In Press, Corrected Proof — Note to users

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC ☆

Universally Available

This paper is dedicated to the memory of our colleagues who worked on CMS but have since passed away. In recognition of their many contributions to the achievement of this observation.

CMS Collaboration*

CERN, Switzerland

S. Chatrchyan, V. Khachatryan, A.M. Sirunyan, A. Tumasyan

Yerevan Physics Institute, Yerevan, Armenia

W. Adam, E. Aguilo, T. Bergauer, M. Dragicevic, J. Erö, C. Fabjan[1], M. Friedl, R. Frühwirth[1], V.M. Ghete, J. Hammer, M. Hoch, N. Hörmann, J. Hrubec, M. Jeitler[1], W. Kiesenhofer, V. Knünz, M. Krammer[1], I. Krätschmer, D. Liko, W. Majerotto, I. Mikulec, M. Pernicka†, B. Rahbaran, C. Rohringer, H. Rohringer, R. Schöfbeck, J. Strauss, F. Szoncsó, A. Taurok, W. Waltenberger, G. Walzel, E. Widl, C.-E. Wulz[1]

Institut für Hochenergiephysik der OeAW, Wien, Austria

V. Chekhovsky, I. Emeliantchik, A. Litomin, V. Makarenko, V. Mossolov, N. Shumeiko, A. Solin, R. Stefanovitch, J. Suarez Gonzalez

32 siders artikkel – 16 sider med forfattere ☺

The Ashlad and His Good Helpers : illustrating the BEH Mechanism

Get me water, within 3 minutes, from the end of the world!”

Hold on – what is happening? The man removes his weights!

“Your Majesty, I will be straight back!”

Some 15 seconds after departure our friend is back!

This man is certainly not made by matter influenced by the Brout-Englert-Higgs (BEH) mechanism.

Norge og CERN

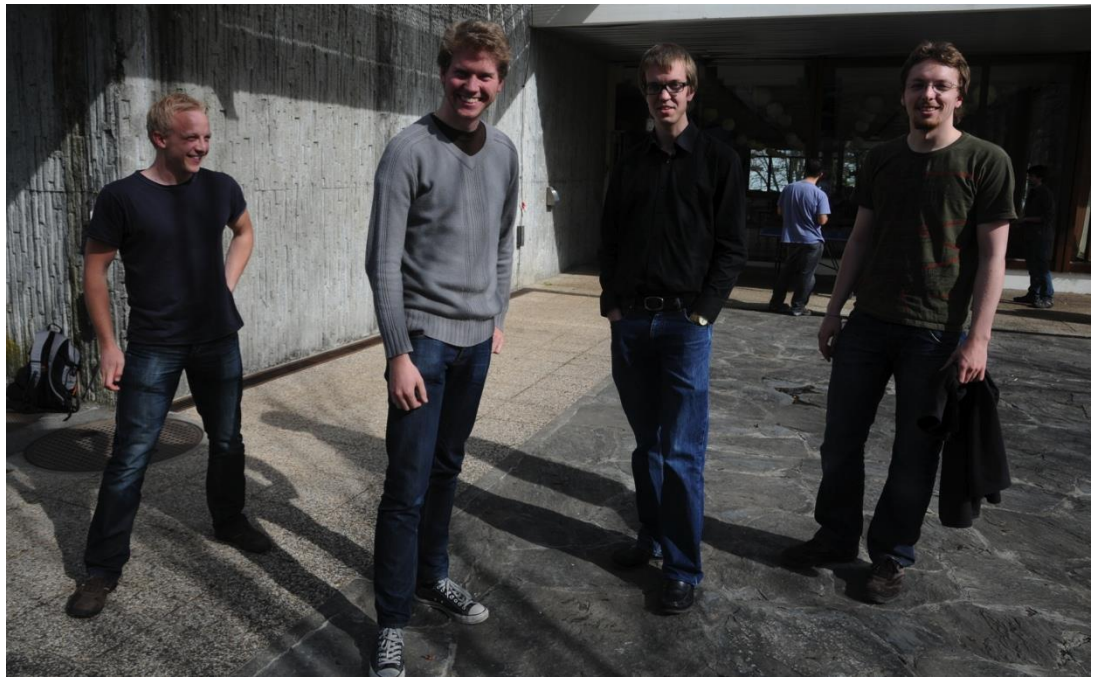
Medlem siden starten i 1954

Medlemskontingent 2022

- Norge: 2,3 %
  - 26 636 300 CHF

CERNs totale budsjett:

1,4 milliarder CHF



Norske tekniske studenter

- Bachelor
- Master

Hva tilsvarer CERN-budsjettet?


E24

OSLO -0,28% OLJE 1,18% S&P 0,03% EURO 0,26% DOLLAR -4,99% BITCOIN

LOGG INN MENY

Solgte Teslaer for 2,9 milliarder kroner

Bilprodusenten taper penger globalt, men i Norge går det så det suser.

FOTO: HANNE HATTREM VG

SALGSUKSESS: Tesla Motor Norway solgte biler for 2,9 milliarder kroner i 2016.

Sindre Hopland

(E24) Publisert: 23.12 - 21.08.2017, Oppdatert: 19:00 - 22.08.2017

Tesla Norge økte resultatet betraktelig fra året før på tross av de solgte færre biler.

Selskapet endte på 30,7 millioner i driftsresultat i 2016,

DEN STORE

- Budsjett NTNU
  - 10 milliarder kroner, hvorav 2,6 milliarder fra eksterne kilder (2021)
  - Kilde: https://www.ntnu.no/tall-og-fakta
- Budsjett ETH
  - 1.896 milliarder CHF (2021)
  - Kilde: https://en.wikipedia.org/wiki/ETH_Zurich


Hegnar.no

NYHETER MARKED FORUM TV EVENT BOK

Nav-anslag: Trygdesvindel for 8 milliarder kroner årlig

Anslag viser at det svindles trygd for rundt 8 milliarder kroner hvert år. I tillegg kommer skatte- og avgiftssvindel på flere titalls milliarder.

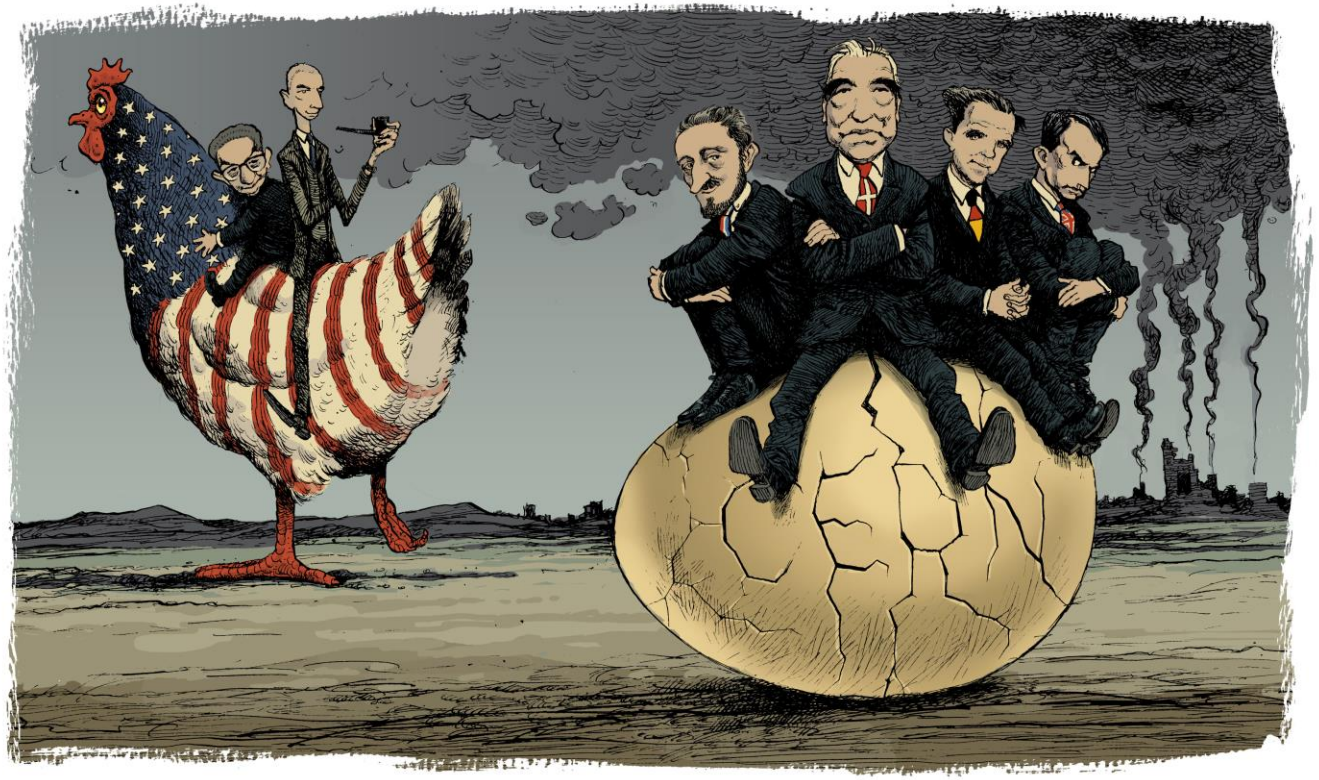
Historikk

UNESCO konferanse

- Lausanne 1949

Pre-CERN 1952

CERN 1954



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

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

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 – 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

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

Non-Member States and Territories **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

MINISTERE ROYAL
DES
AFFAIRES ETRANGERES

(Original: English)

Oslo, 22 July 1952

Professor E. Amaldi,
Secretary-General of the Council
of Nuclear Research
Istituto di Fisica
Rome

Sir,

With reference to your letter of 21st May, 1952, I have the honour of informing you that the Norwegian Government on 17th July decided to reply as follows to the Council:

Norway is interested in the plans for the establishment of a European Laboratory for Nuclear Research. As far as Norway is concerned it will, therefore, be considered to offer a suitable site for this purpose. However, the Government does not at the present time have sufficient information regarding these plans in order to make a final decision. It is therefore requested that such information be furnished. As the National Assembly is not in session, no offer to place a site at disposal can be made at present.

I have the honour to be,
Sir,
Your obedient Servant,

For the Minister
(signed)

Secretary-General

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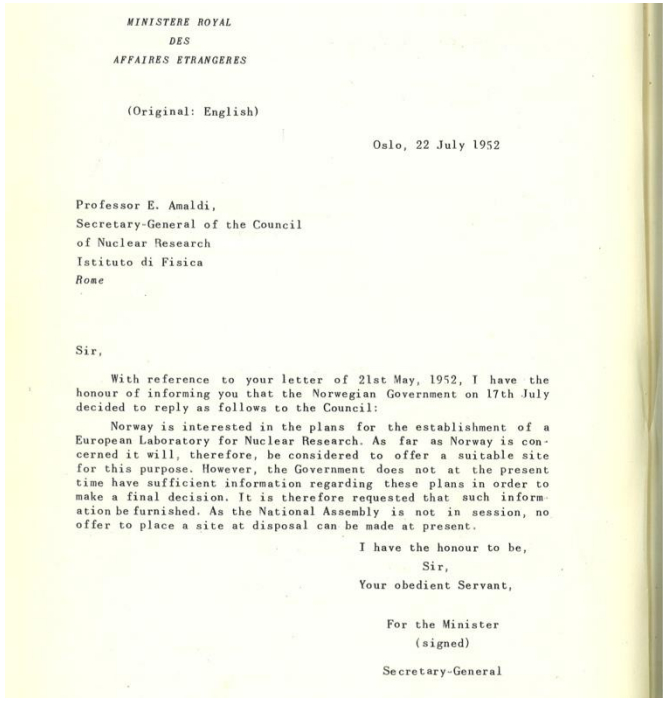

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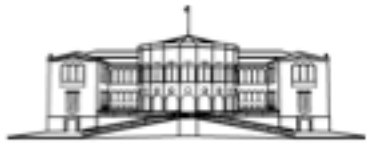
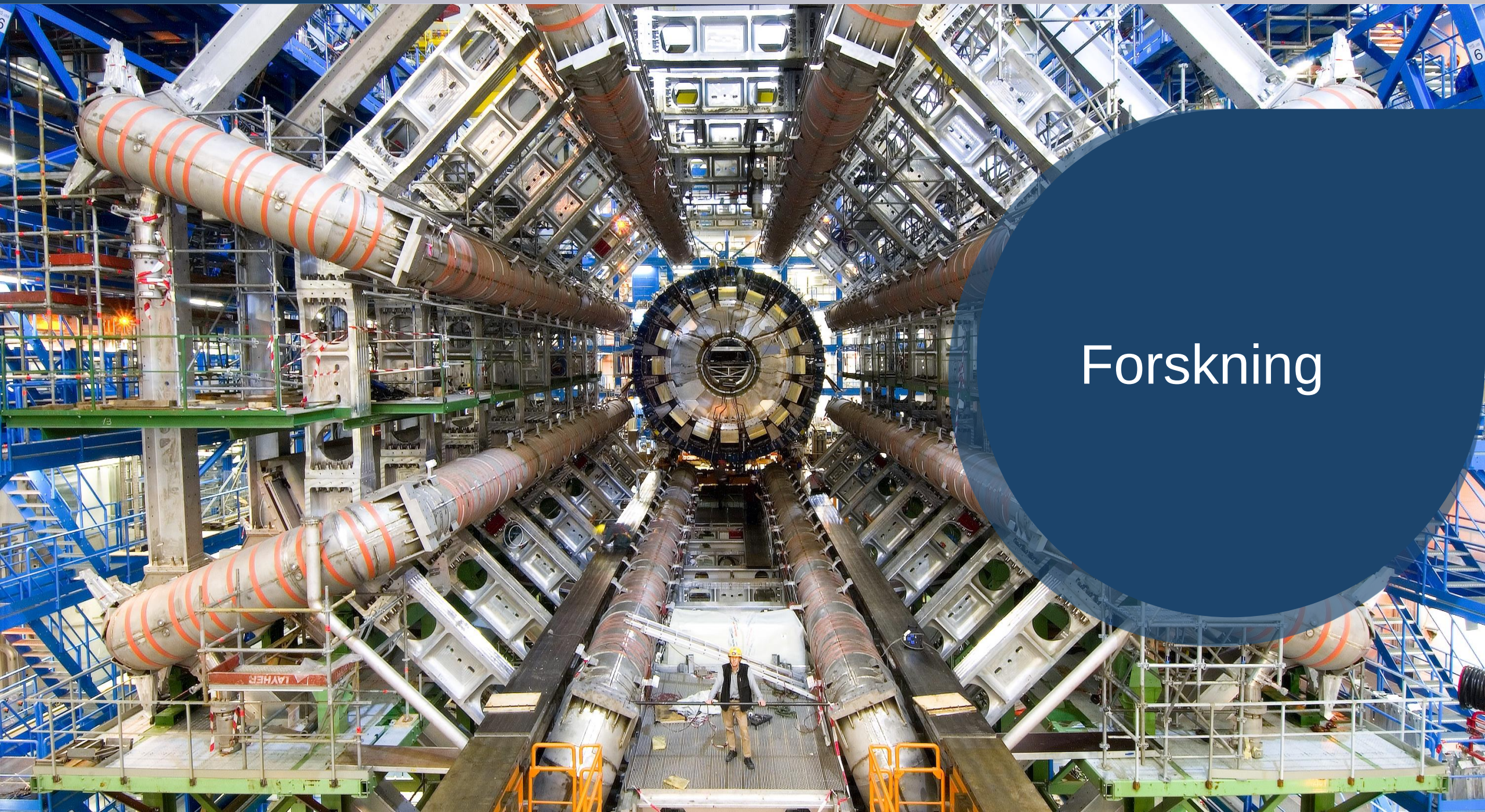
For the Minister
(signed)

Secretary-General

Hadde ikke Stortinget vært på ferie, så hadde kanskje CERN havnet i Norge …



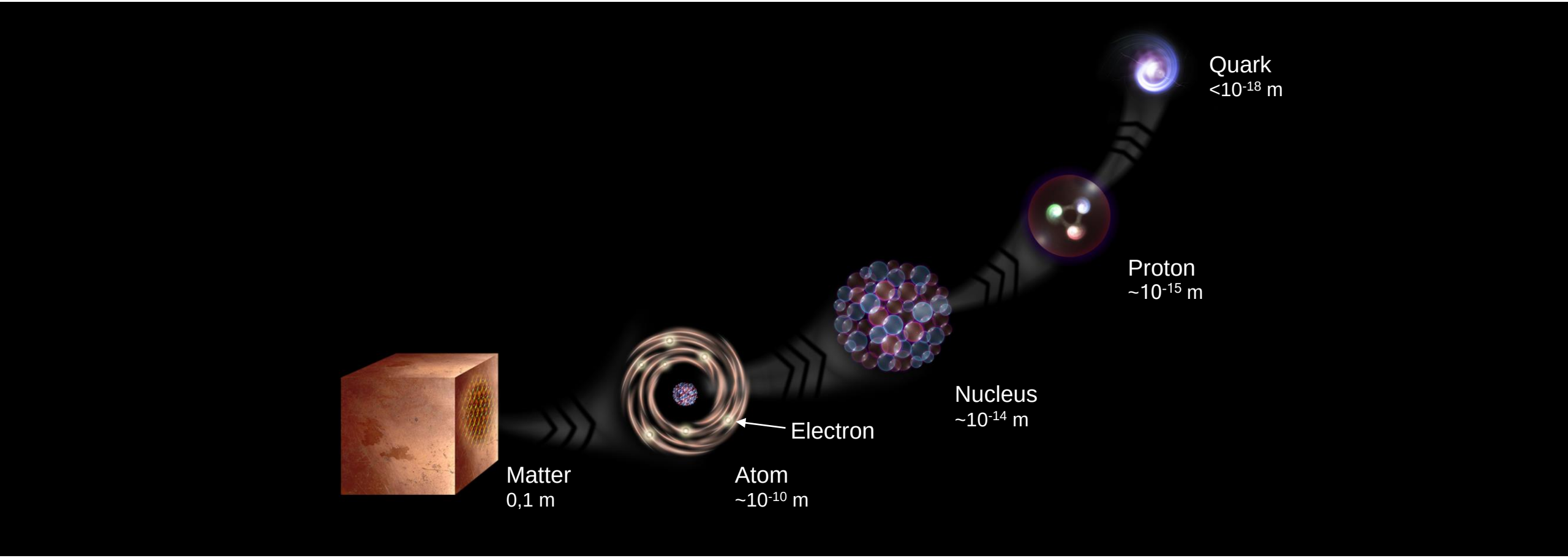
Stortinget

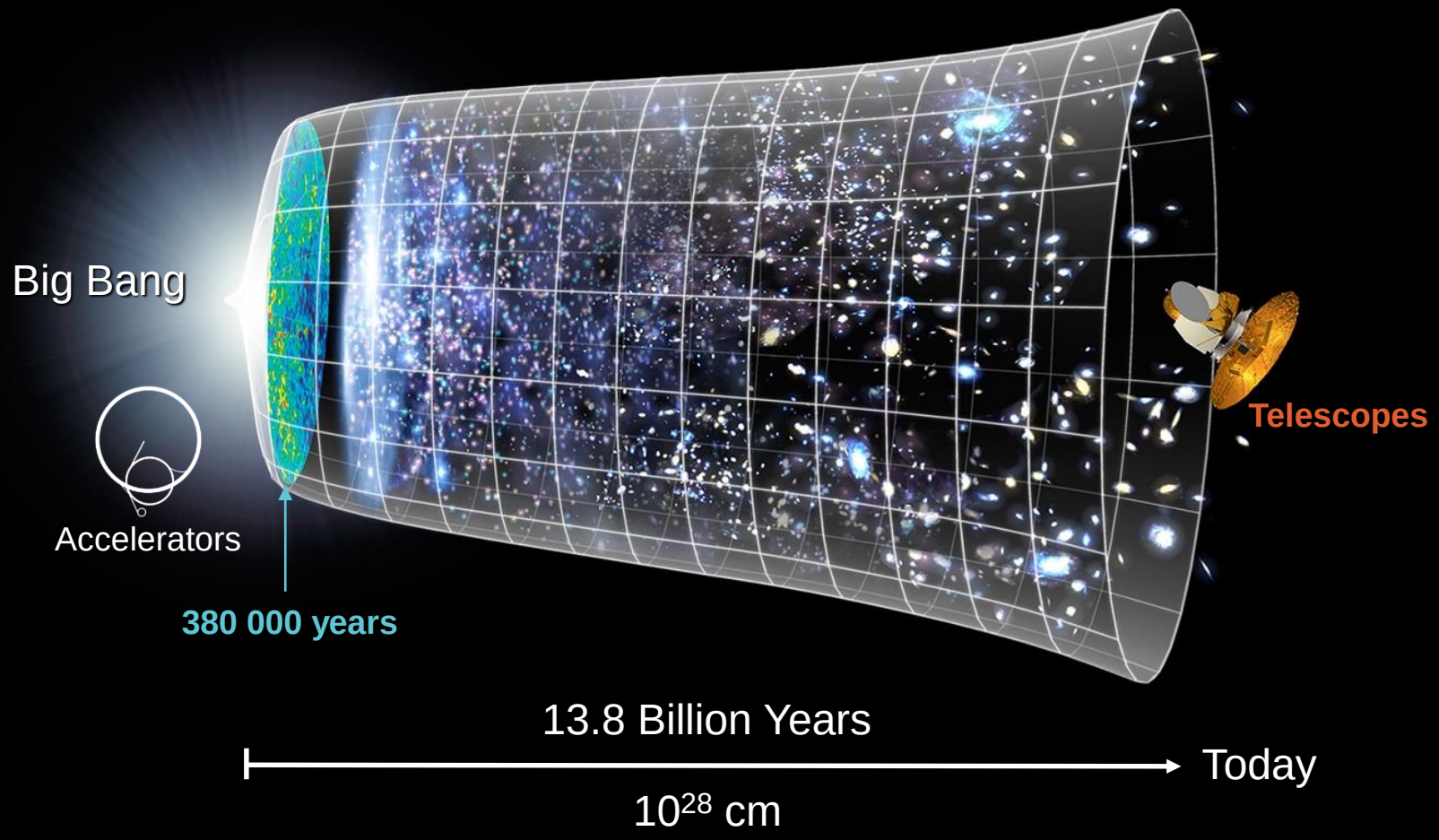


Forskning

Universets bestanddeler

Ved CERN studerer vi universets elementære “byggeklosser” og kreftene som virker mellom dem.





Hvordan oppstod universet?

I eksperimentene ved CERN gjenskaper vi forholdene umiddelbart etter «the Big Bang» for å studere universets struktur og utvikling.

Det finnes fortsatt mange ubesvarte spørsmål

blant andre

95% of the mass and energy of the universe is unknown.

Is there only one Higgs boson, and does it behave exactly as expected?

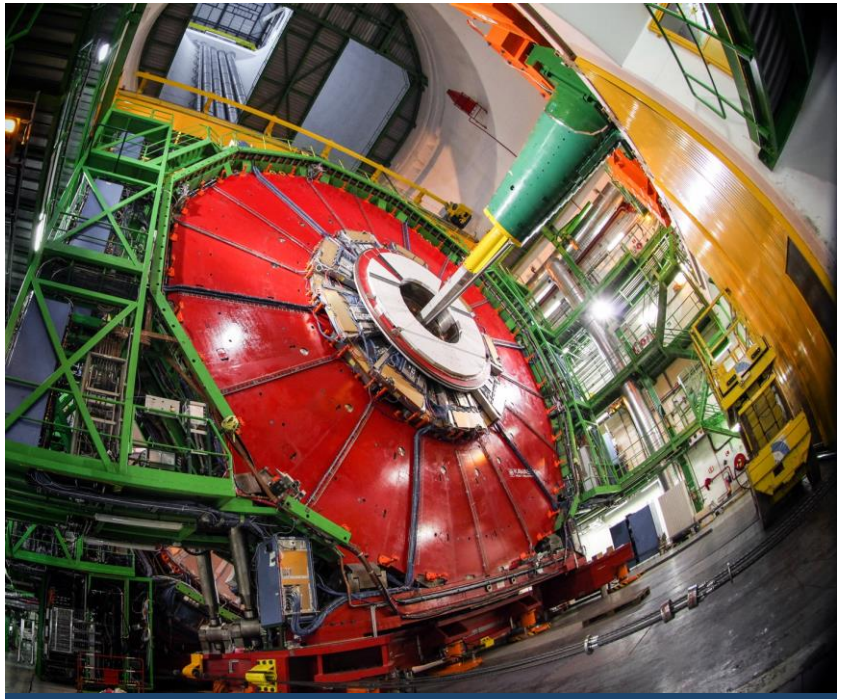
Why is the universe made only of matter, with hardly any antimatter?

Why is gravity so weak compared to the other forces?

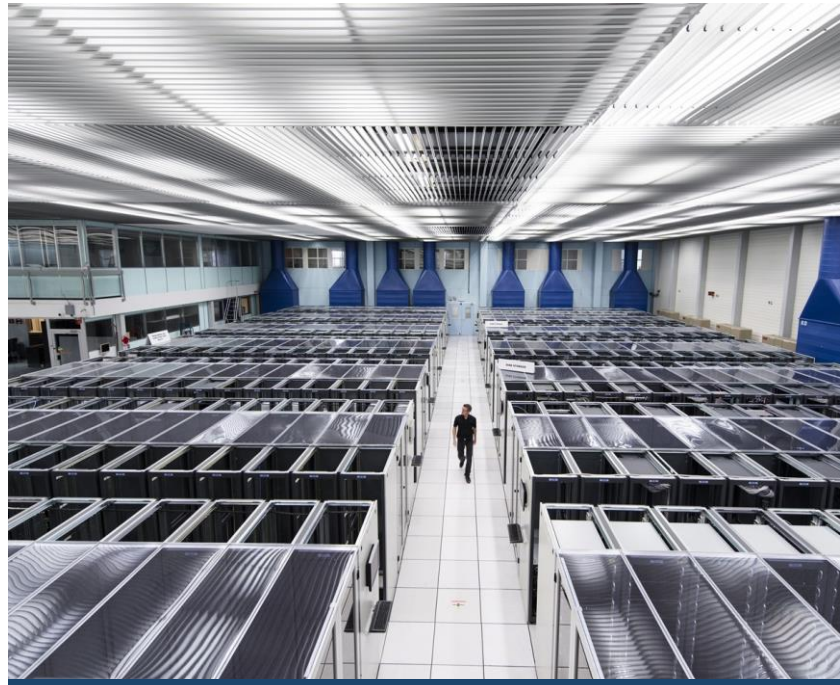
Hvordan gjør vi det?

- Vi bygger enorme instrumenter for å studere universets minste bestanddeler
- Vi utvikler teknologi for å presse grensene for det mulige
- Vi har forskere i verdensklasse innenfor teoretisk og eksperimentell fysikk

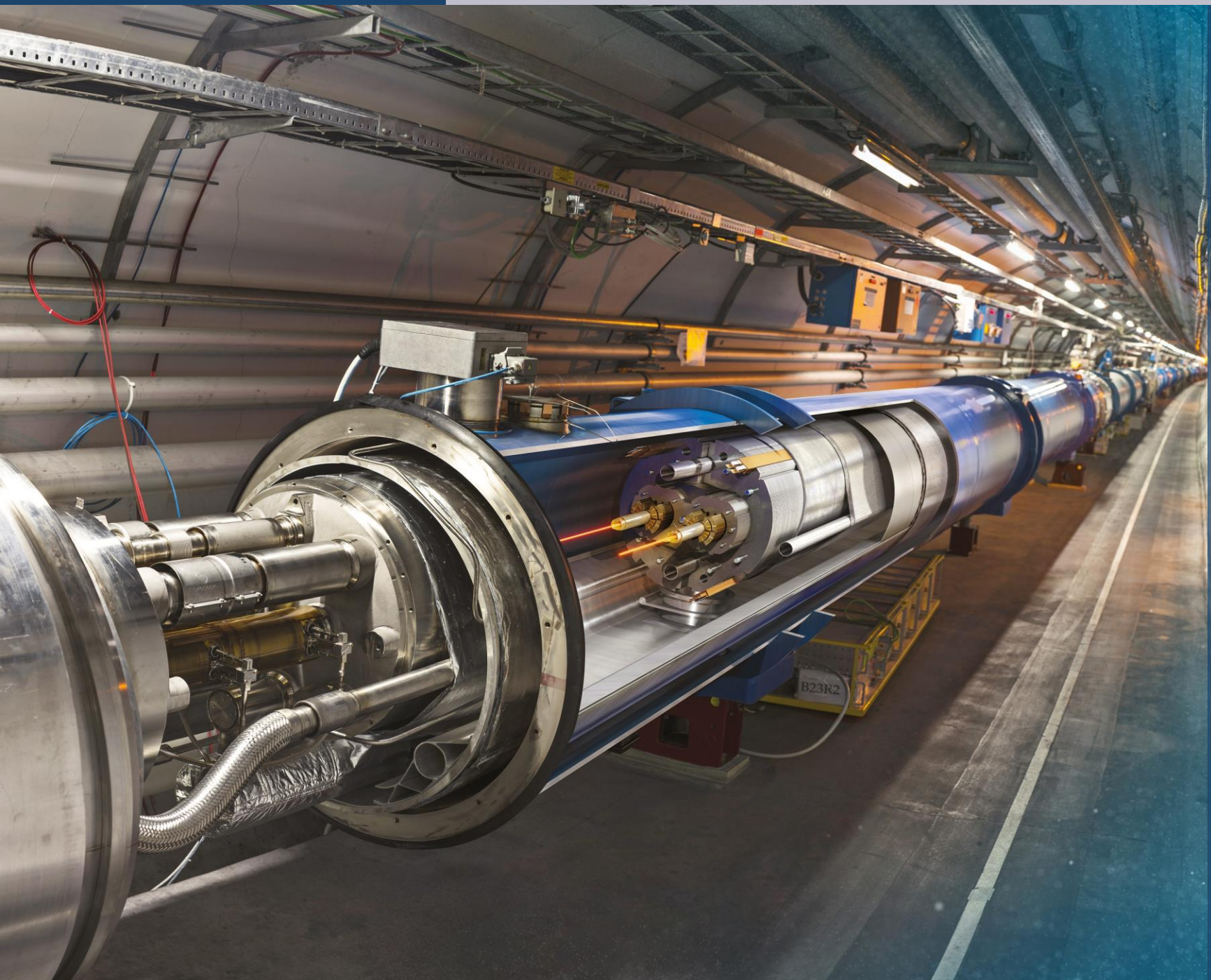
Akseleratorer



Detektorer



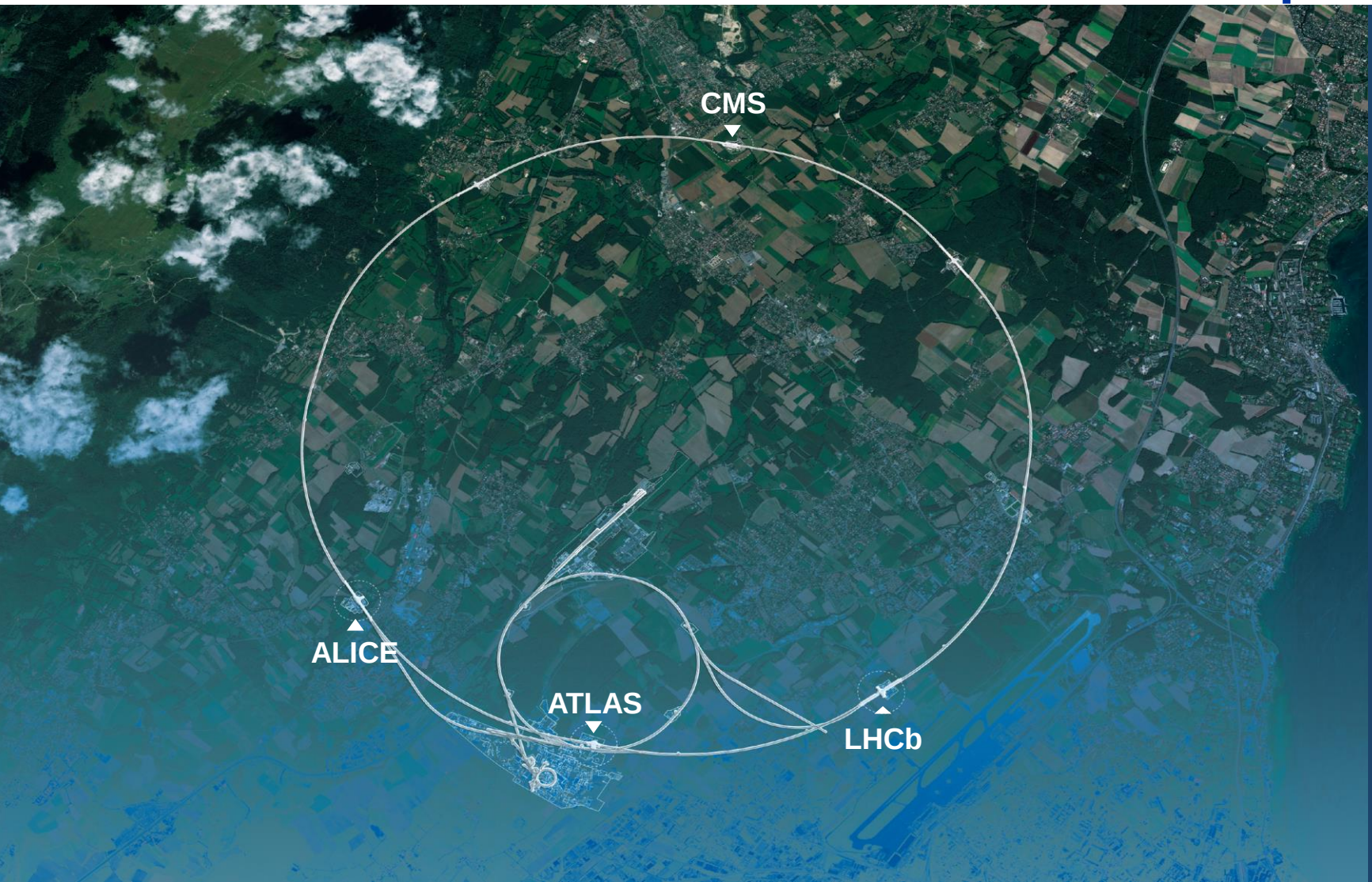
Tung-regning

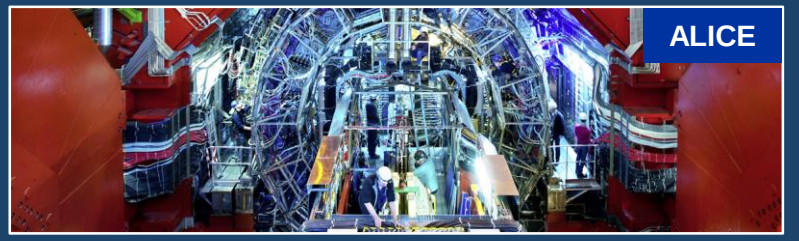


Large Hadron Collider (LHC)

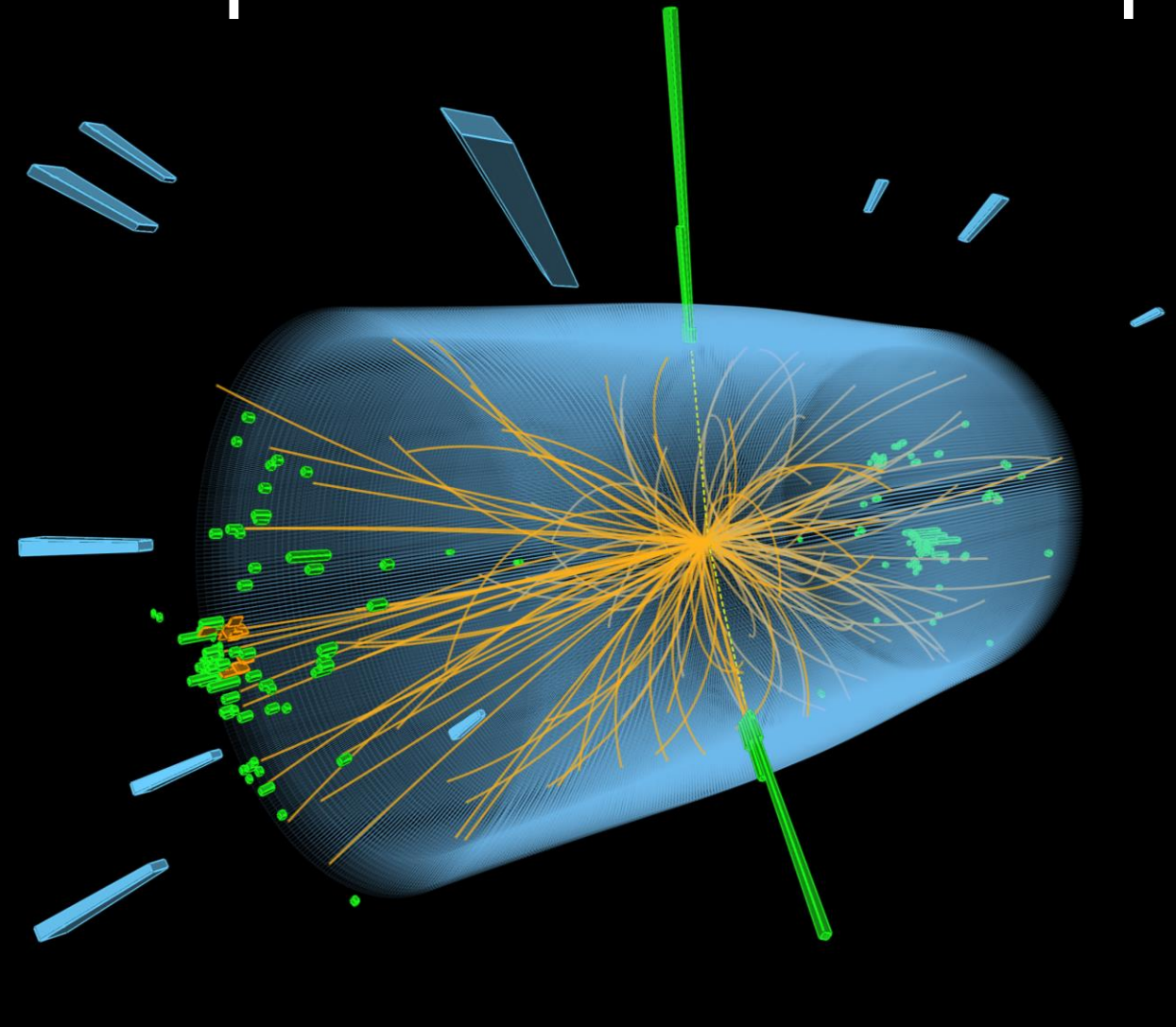
- ~27 km i omkrets
- ~100 m under bakken
- Supraledende magneter leder partiklene rundt ringen
- Partiklene akselereres (nesten) opp til lyshastigheten

Giant detectors record the particles formed at the four collision points





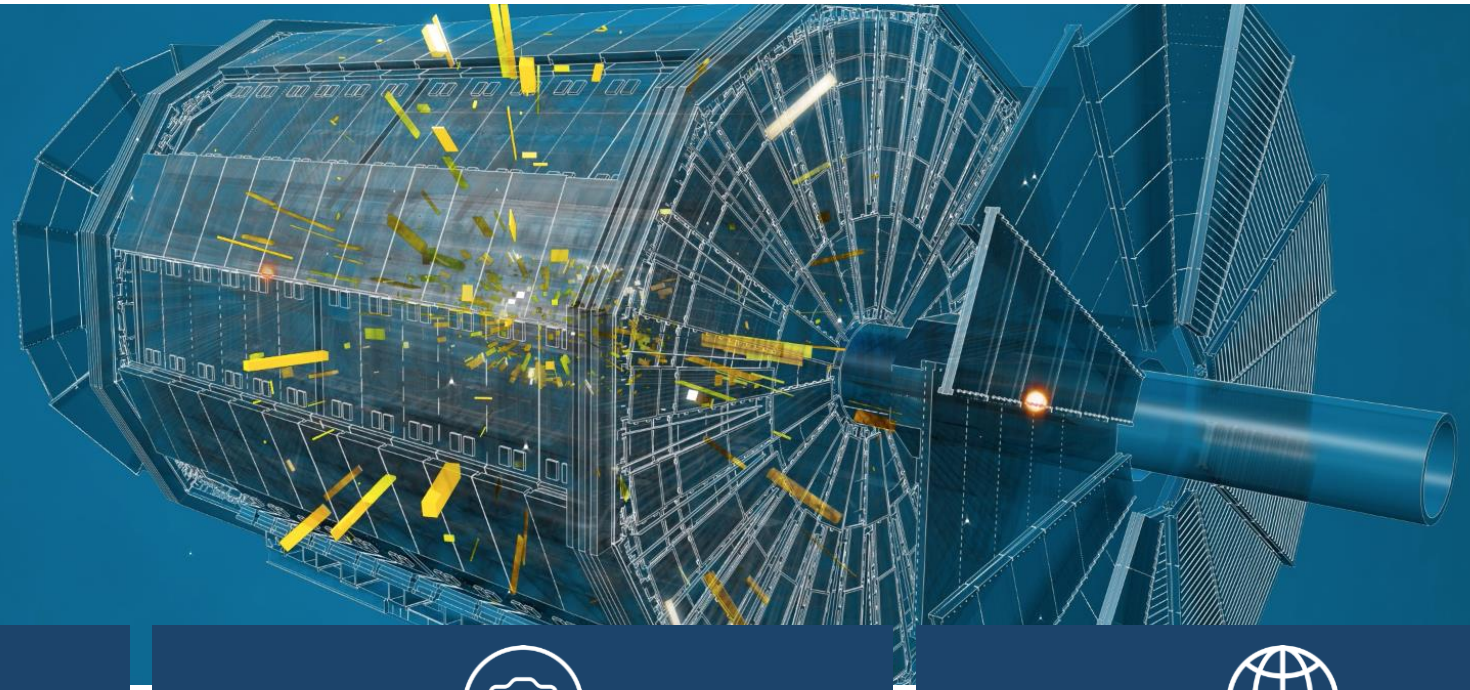
LHC produserer mer enn *en milliard* partikkelkollisioner per sekund



Partiklenes energi i kollisjonene omdannes til nye partikler.

$E=mc^2$

The LHC detectors are analogous to 3D cameras

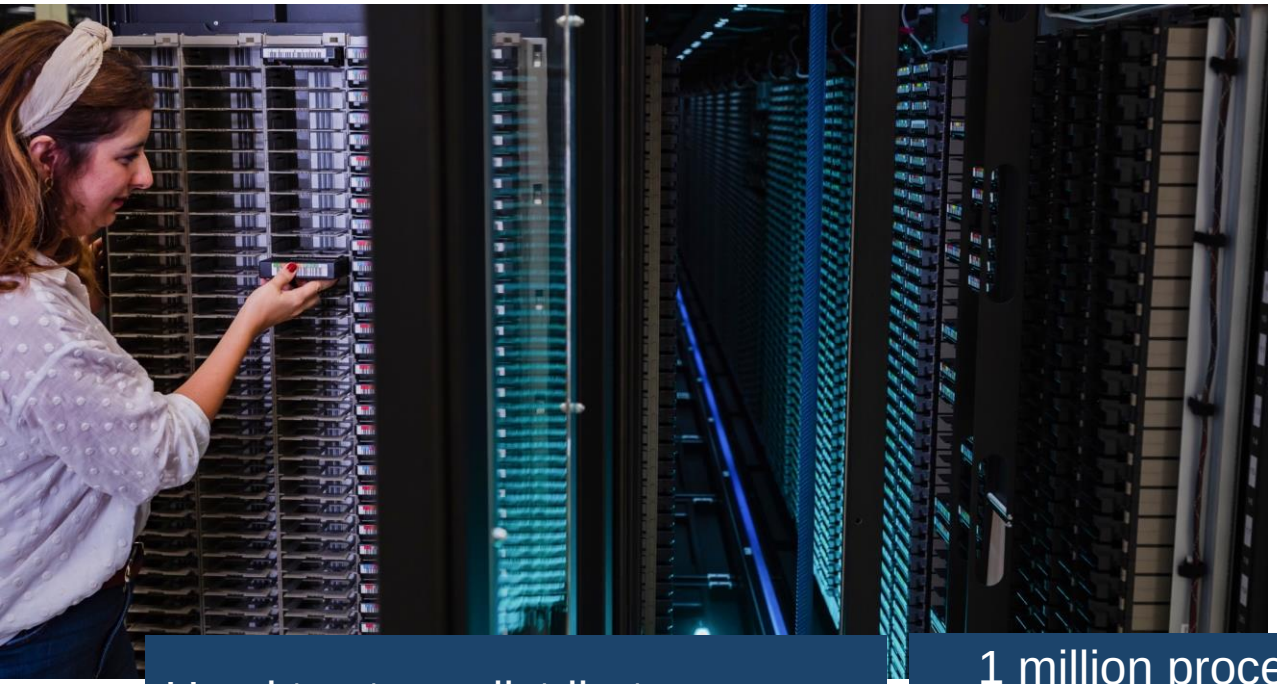


The detectors measure the energy, direction and charge of new particles formed.

They take 40 million pictures a second. Only 1000 are recorded and stored.

The LHC detectors have been built by international collaborations covering all regions of the Globe.

The Worldwide LHC Computing Grid (WLCG)



Used to store, distribute, process and analyse data.

1 million processing cores in about 170 data centres and 42 countries.

More than 1000 Petabytes of CERN data stored world-wide.

Teknologi og innovasjon

CERN’s technological innovations have applications in many fields

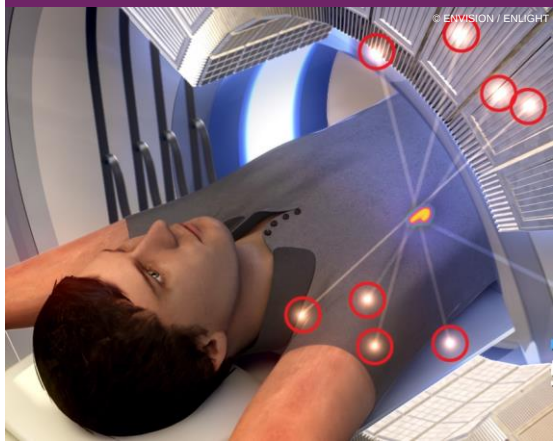
CERN is the birthplace of the World Wide Web

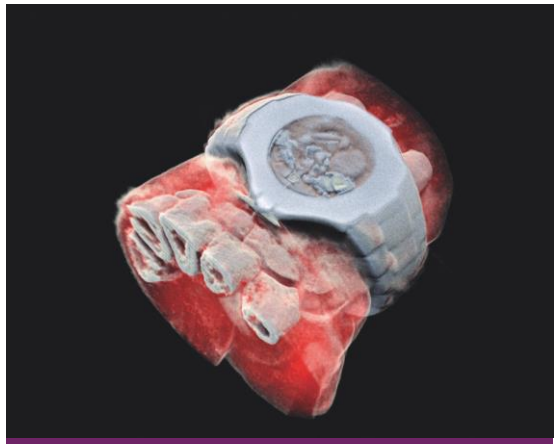
And there are many more examples
Medical imaging, cancer therapy, material science, cultural heritage, aerospace, automotive, environment, health & safety, industrial processes.

CERN’s technological innovations have important applications in medicine and healthcare

Strålebehandling
Accelerator technologies are applied in cancer radiotherapy with protons, ions and electrons.

Positronemisjons-tomografi
Technologies applied at CERN are also used in PET, for medical imaging and diagnostics.



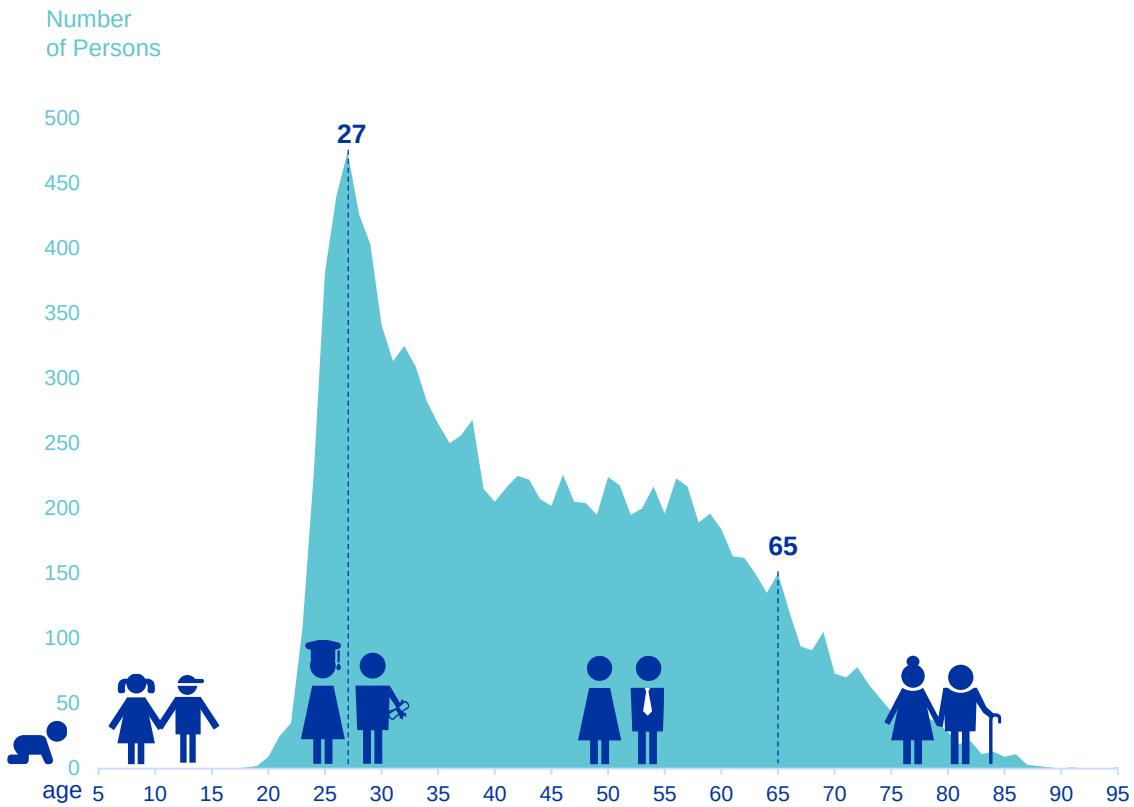


Radiografi
Pixel detector technologies are used for high resolution 3D colour X-ray imaging.

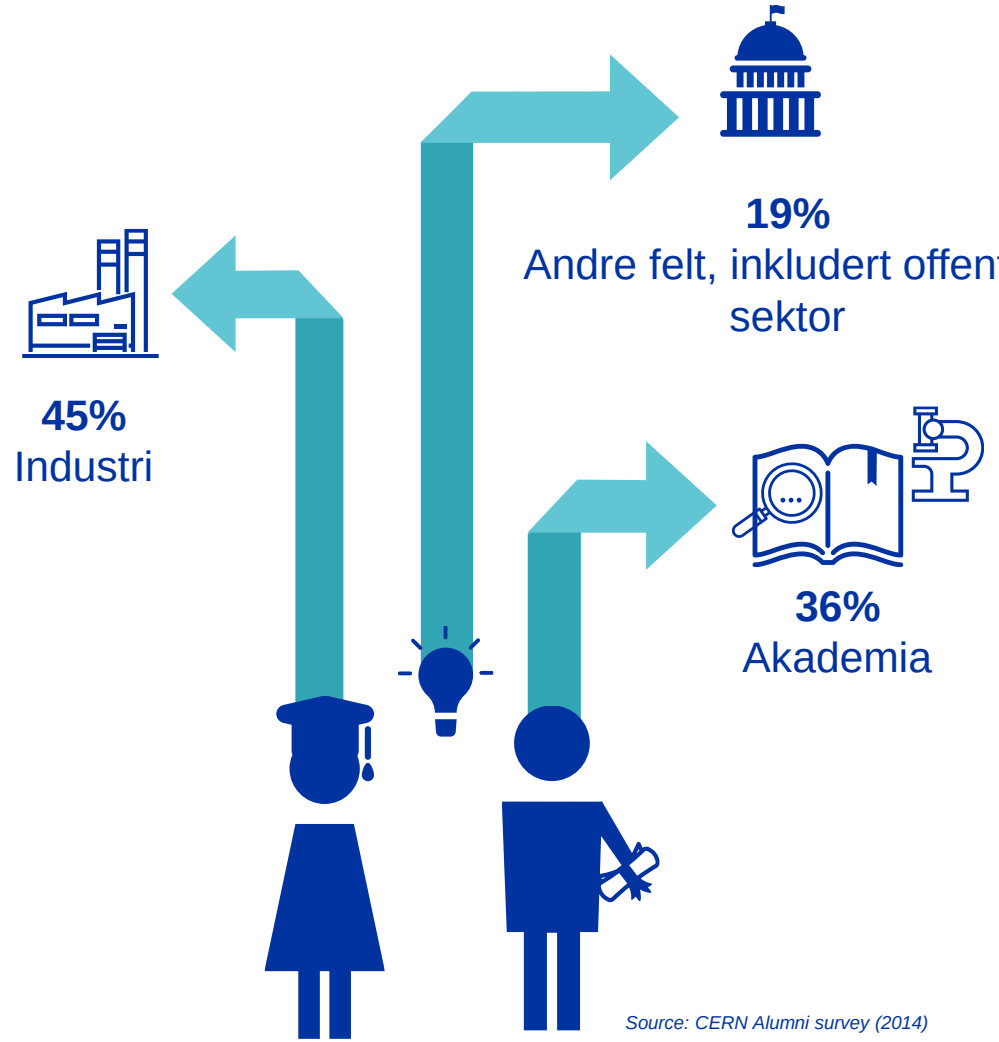
Radionuklider for nukleærmedisin
CERN produces innovative radioisotopes for nuclear medicine research.

Opplæring og utdanning

CERN åpner mange karrieremuligheter



Forskernes aldersfordelingen ved CERN



PhD- og masterstudenter som forlater CERN

CERNs opplæring- og utdanningsprogram

300 undergraduate students in Summer programmes
>3000 registered PhD students.

>1000 fellows, technical and doctoral students in research and applied physics, engineering and computing.

13 304 teachers since 1998 and 2000 participants in the webinar since 2020.

Numbers for Norway

3 summer students during 2019
158 teachers in Teacher Programmes since 1998
2 teams in BL4S competition since 2014
800 students participating in S'Cool LAB since 2015
1444 visitors in 2019

151 000 visitors on guided tours of CERN in 2019, from 95 countries.

CERN engages with citizens across the globe:
on-site and travelling exhibitions in 15 countries, > 1 million visitors

Science Gateway will open in 2023, expanding CERN's outreach reach and impact, locally and globally.

Dagbladet 2. oktober 2019:

Det jeg derimot ikke imponeres av er Kjærstad hang til å gjøre sine helter og heltinner til spesielt utrustede genier. Her møter vi riktignok ingen magiske peniser, men en «briljant» bibliotekar og en Nobelprisvinner i fysikk.

Film


DECAY
THE GREATEST DISCOVERY IN PHYSICS COULD BE OUR LAST.
PARTICLEFEVER

“Typisk norsk å være god ...”

Gro Harlem Brundtland under de Olympiske leker i 1994

Gjelder dette også akselerator- og partikkelfysikk?

- Sophus Lie (1842-1899) – matematisk grunnlag
- Kristian Birkeland (1867-1917) – “The first space scientist”
- Odd Dahl (1898-1994) “Trollmann og rundbrenner”
- Rolf Widerøe (1902-1996) – “Besatt av en drøm”
- Kjell Johnsen (1921-2008) – Ledet ISR prosjektet
- Bjørn Wiik (1937-1999) – Direktør ved DESY

Hvem blir den neste på lista?—deg?