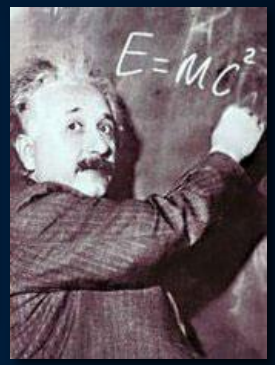
Welcome - Velkommen

to CERN Accelerating Science and Innovation

The Mission of CERN

- **Push back** the frontiers of knowledge

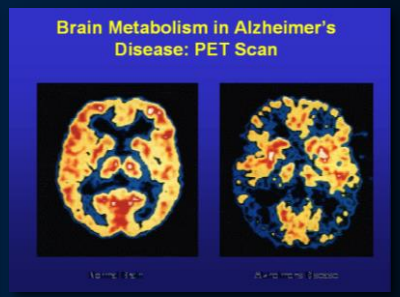
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



- **Develop** new technologies for accelerators and detectors

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy



- **Train** scientists and engineers of tomorrow

- **Unite** people from different countries and cultures

CERN: founded in 1954: 12 European States
"Science for Peace"
Today: 23 Member States

Employees: ~2700 staff, 800 fellows
Associates: ~12600 users, 1800 others
Budget (2019) ~ 1200 MCHF

Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom

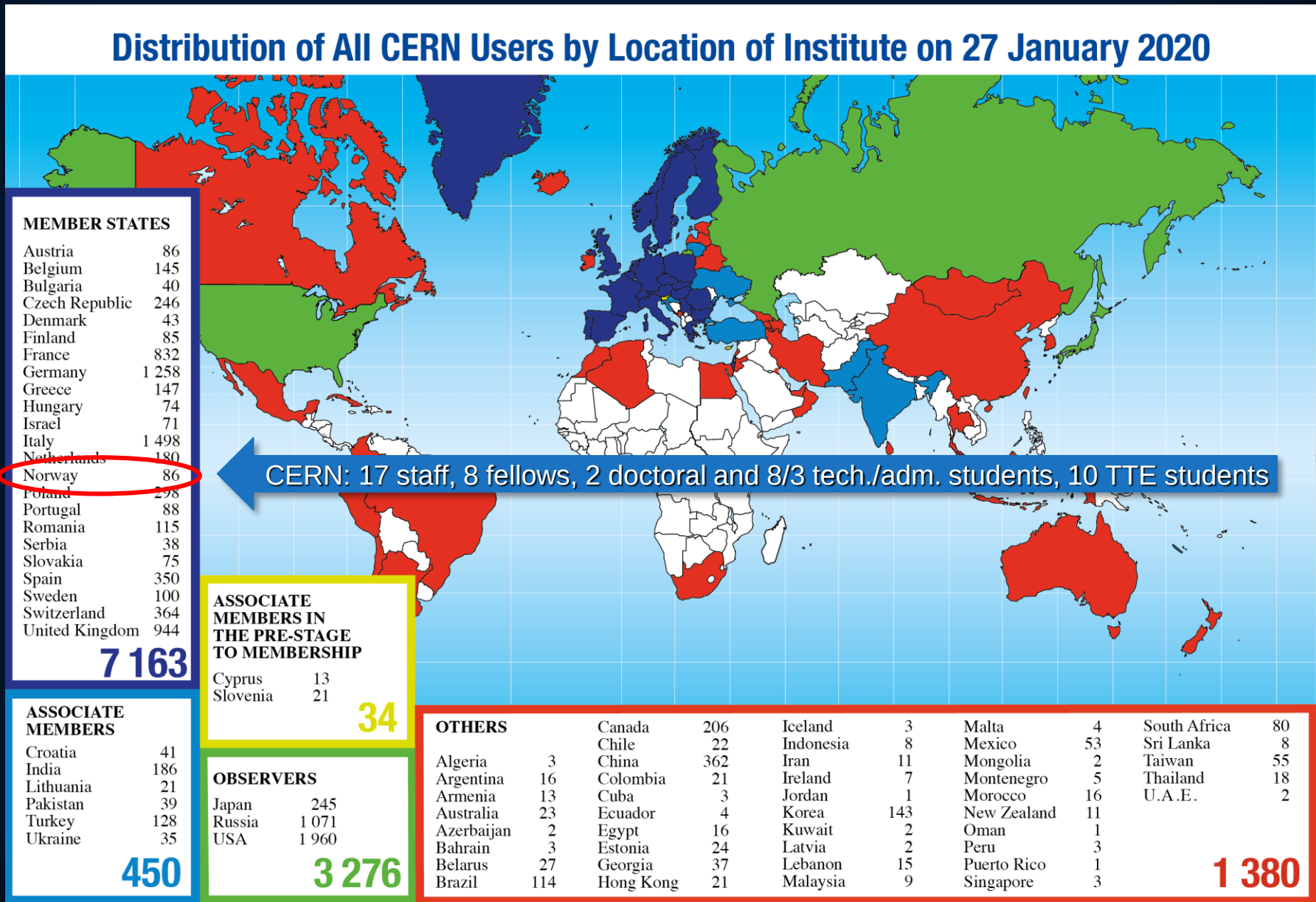
Associate Members in the Pre-Stage to Membership: Cyprus, Slovenia

Associate Member States: Croatia, India, Lithuania, Pakistan, Turkey, Ukraine

Applications for Membership or Associate Membership: Brazil, Estonia

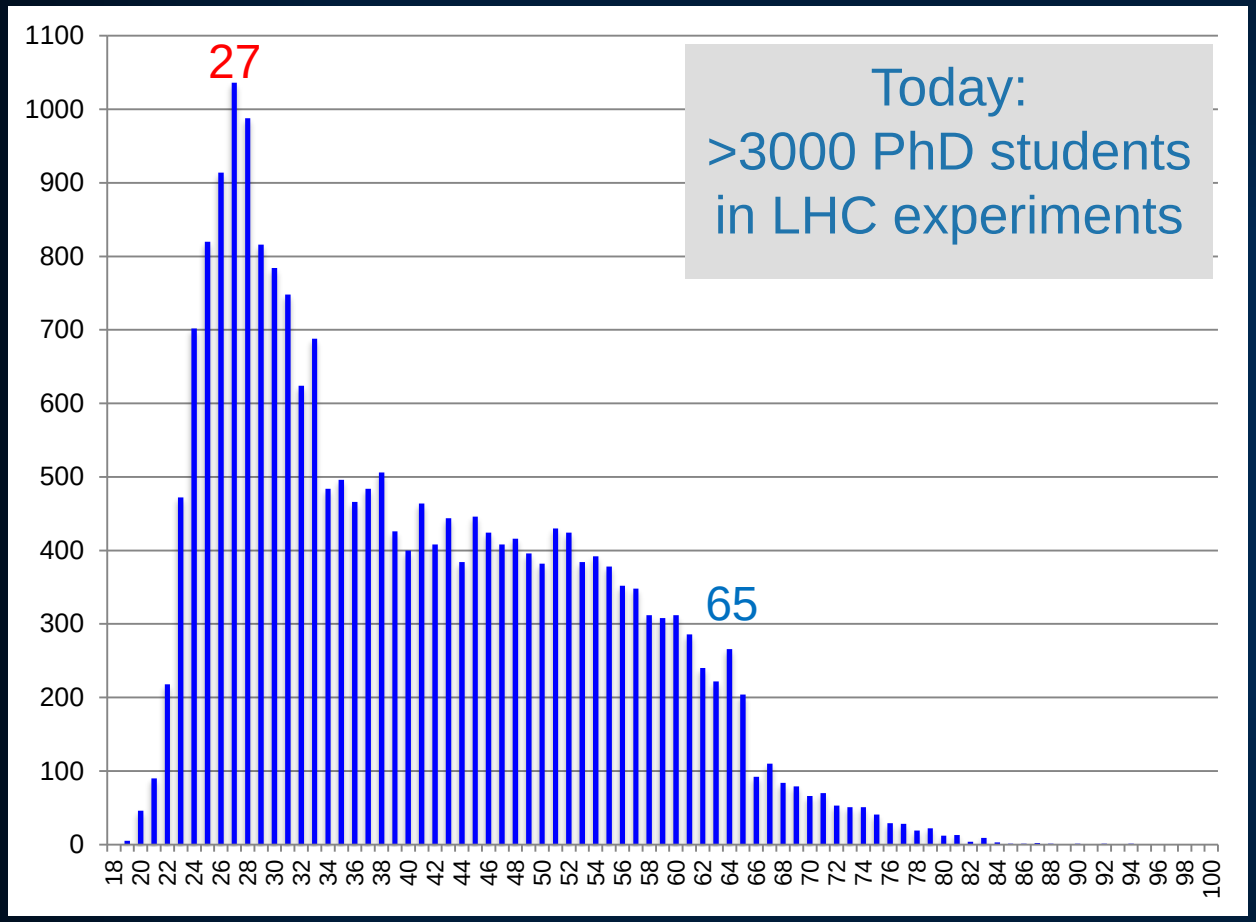
Observers to Council: Japan, Russia, United States of America; European Union, JINR and UNESCO

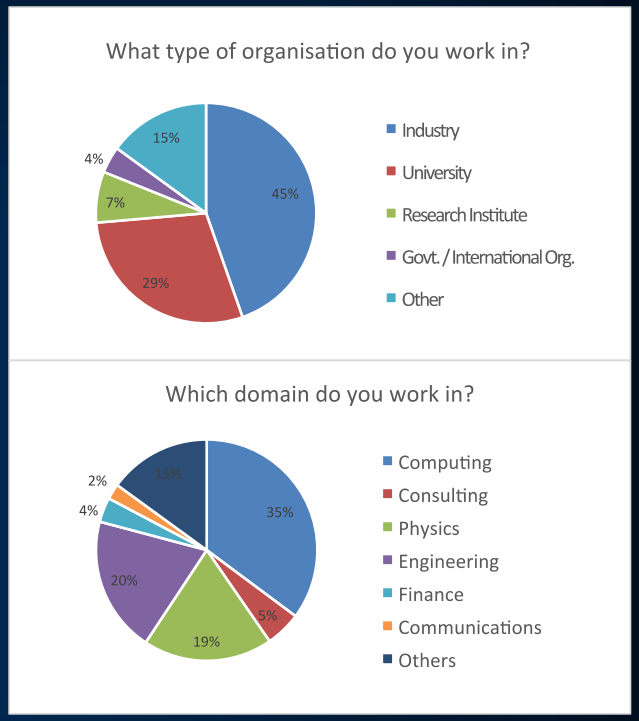
Science is getting more and more global



Age Distribution of Scientists

- and where they go afterwards

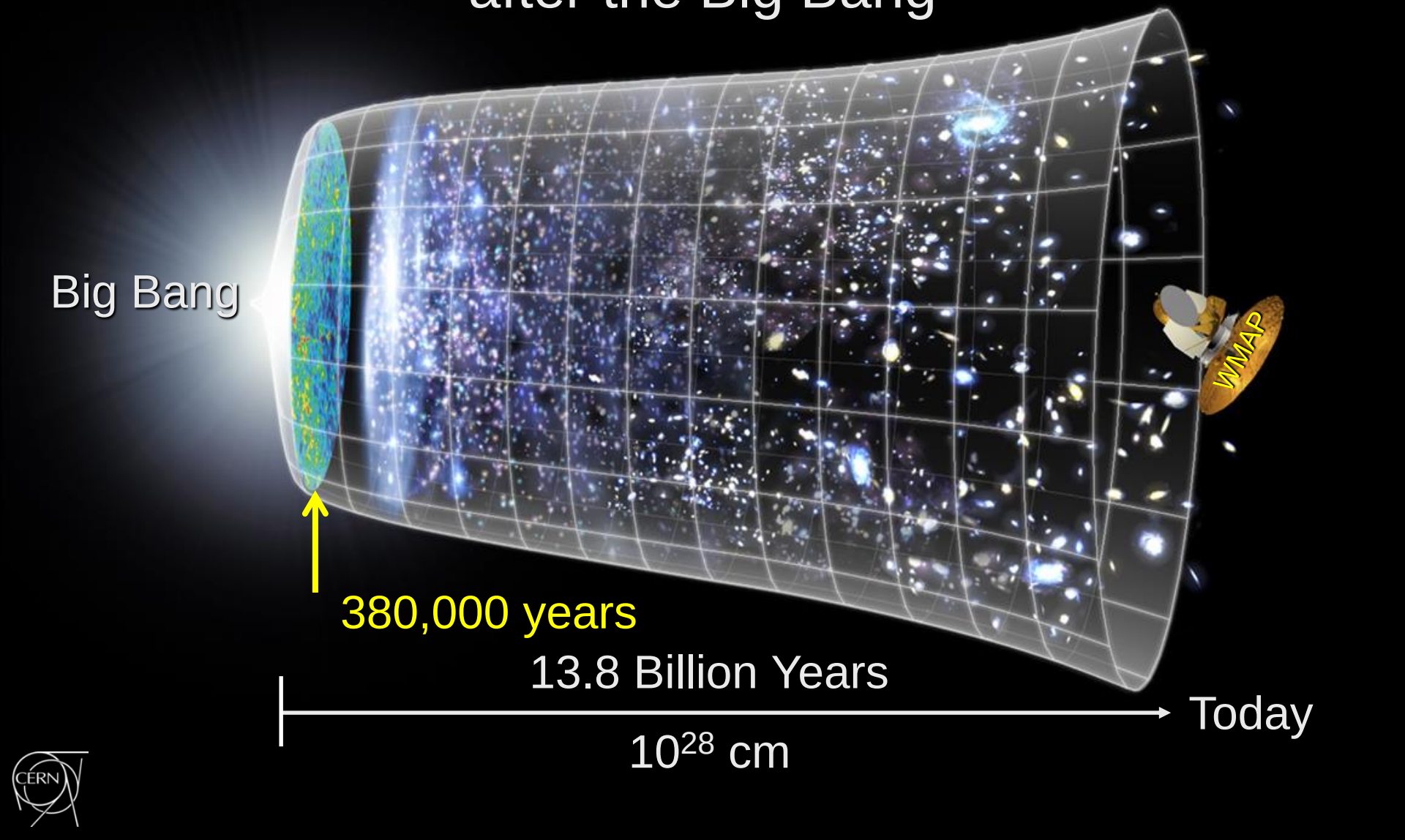


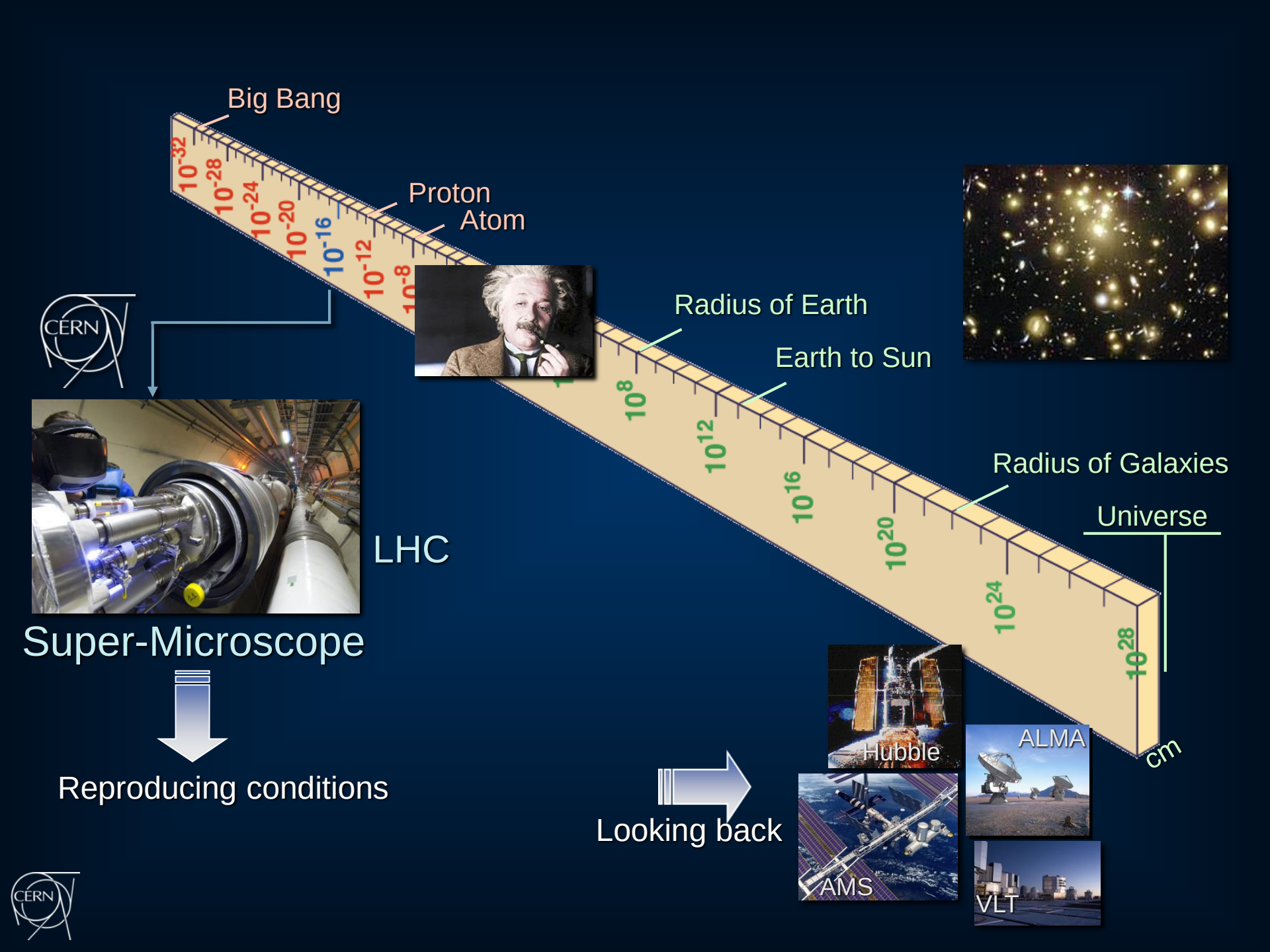


They do not all stay: where do they go?

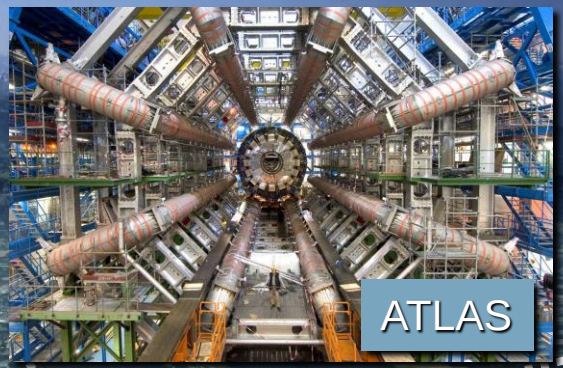
CERN

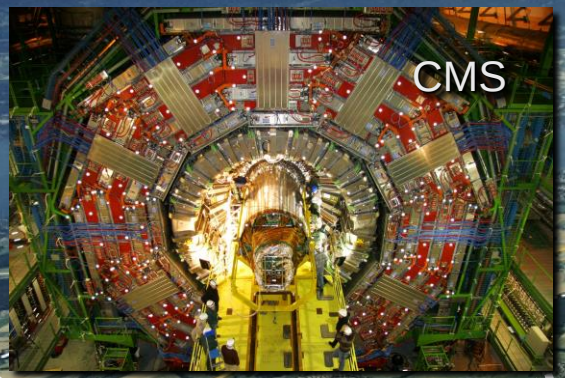
Next Scientific Challenge:
to understand the very first moments of our Universe after the Big Bang




Big Bang
Proton
Atom
Radius of Earth
Earth to Sun
Radius of Galaxies
Universe
cm
LHC
Super-Microscope
Reproducing conditions
Looking back
Hubble
ALMA
AMS
VLT

2010: a New Era in Fundamental Science





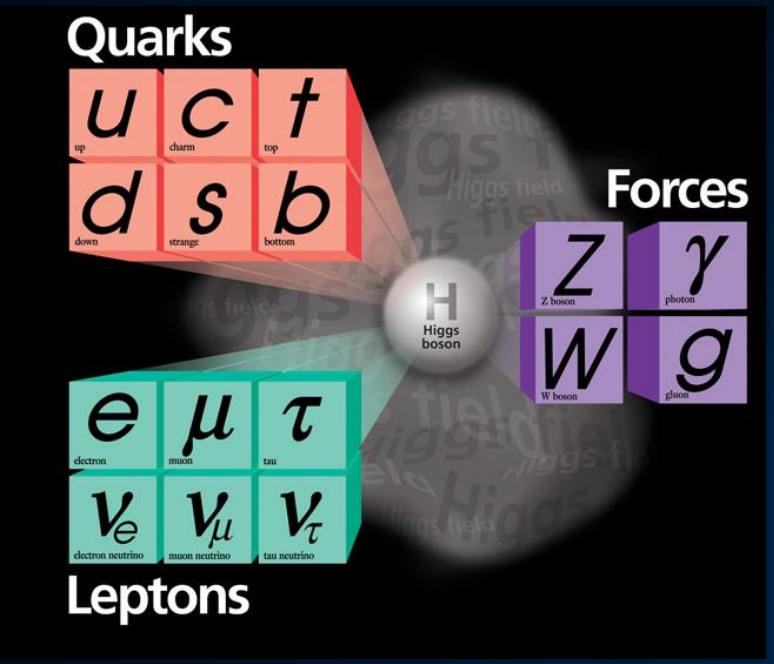
Exploration of a new energy frontier
in p-p and Pb-Pb collisions

CERN

Discovery 2012, Nobel Prize in Physics 2013

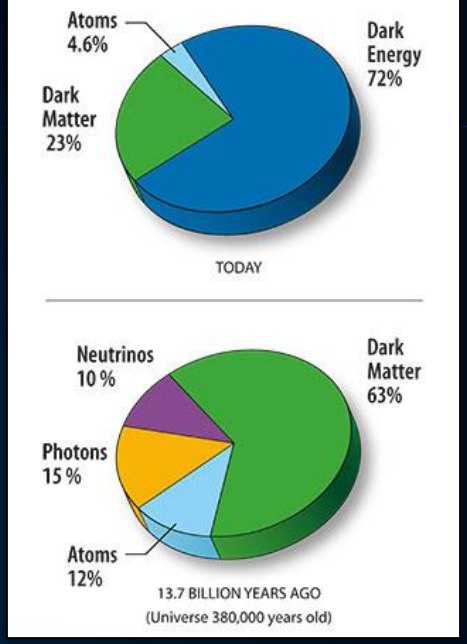
The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental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

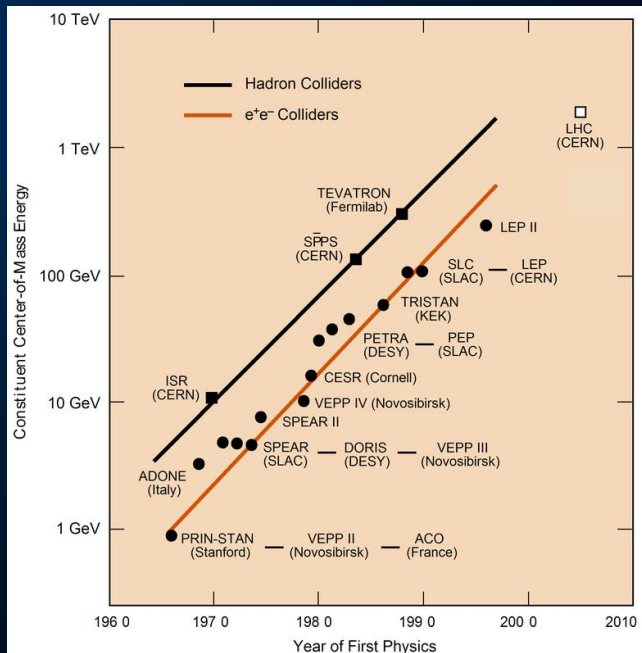
The landscape



"Unknowns:

- Flavour structure
- Matter-antimatter
- Why is the Higgs boson so light
- Neutrino sector
- Forces merging ?
- Gravity
- … and ….
- Dark Matter/Energy

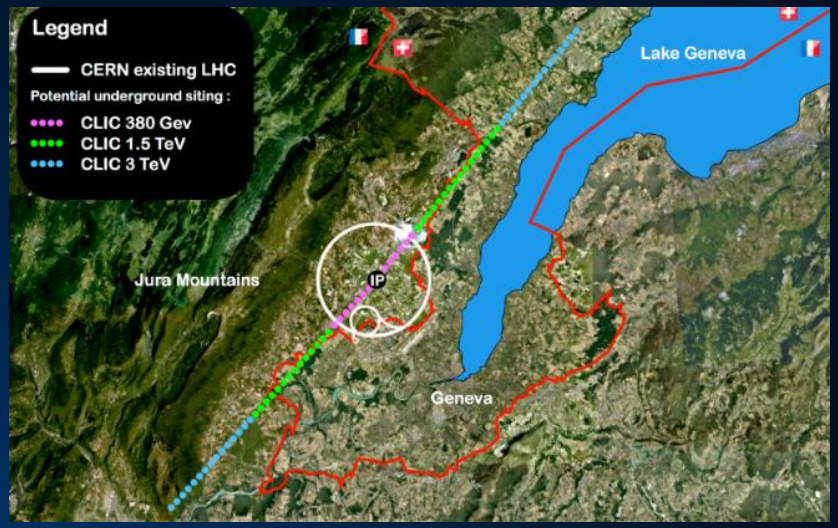




Future of particle physics

High Luminosity LHC until 2040

- Ten times more collisions than the original design

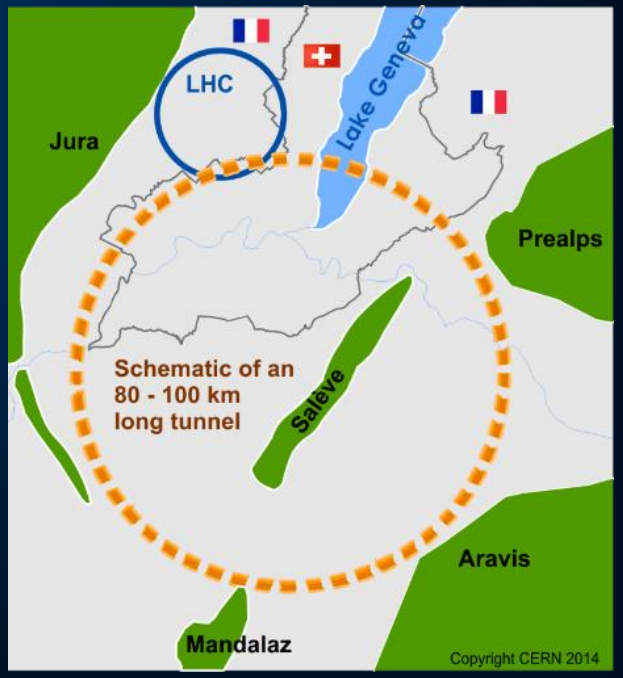


Studies in progress:
Compact Linear Collider (CLIC)

- Linear e^+e^- collider $\sqrt{s}$ up to 3 TeV

Future Circular Collider (FCC)

- New technology magnets → 100 TeV pp collisions in 100km ring
- e^+e^- collider (FCC-ee) as 1st step?

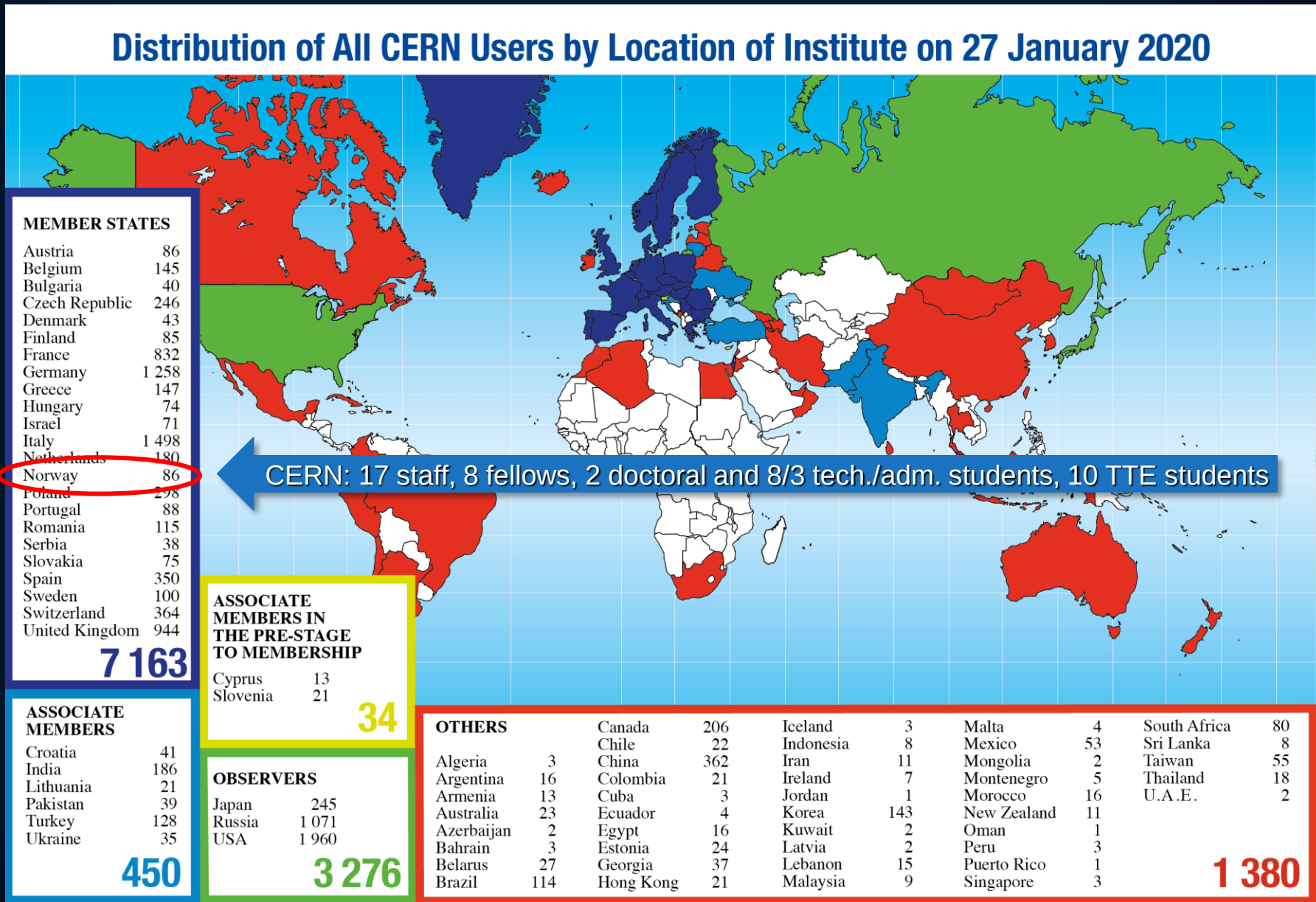


European Strategy for Particle Physics

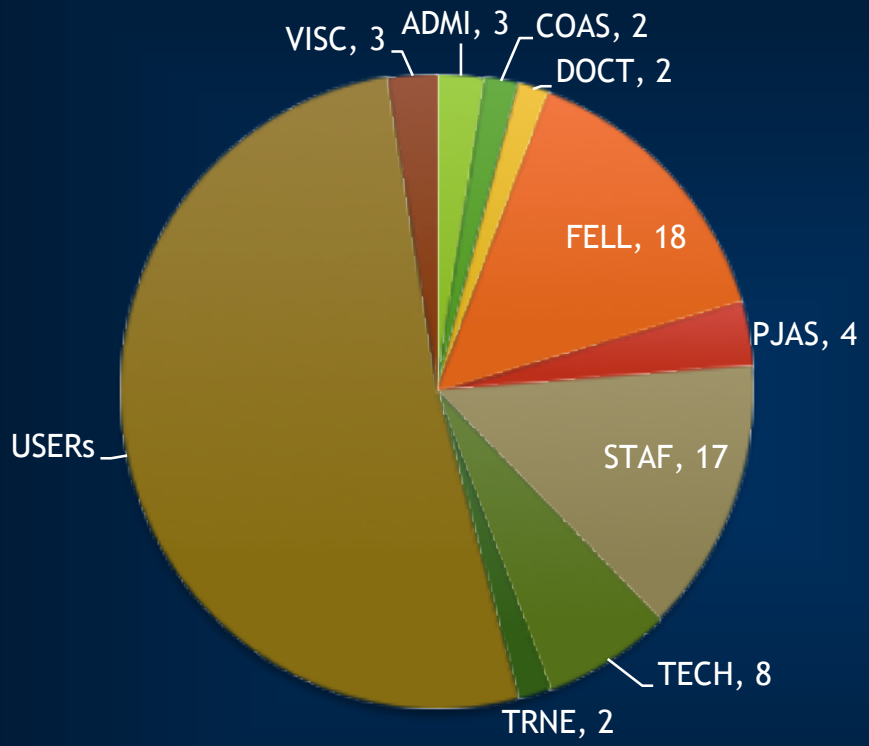
- Preparing next update in 2020

NORWAY AND CERN

Going back to Norway and CERN

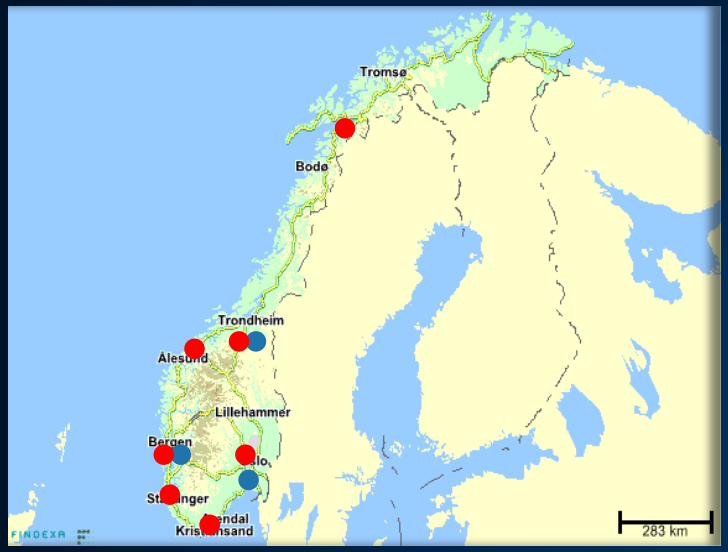


Norwegians at CERN- 17.9.2019



ADMIN: Administrative student
CASS: Cooperation Associates
COAS: Corresponding Associate
DOCT: Doctoral Student
FELL: Fellow
PJAS: Project Associate
STAF: Staff member
TECH: Technical Student
TRNE: Trainee
SASS: Scientific Associate
VISC: Visiting Scientist
USER: User

High Energy Physics in Norway



Blue: Oslo, Bergen, Trondheim: Traditional Universities involved at CERN – UiO, UiB dominates the experimental activities

Red plus NTNU: Main recruitment ground for technical and TTE students

Today around 120-140 Norwegian researchers, engineers, postdocs, PhD students, and master students are involved in the CERN activities:

- Around 90 Norwegian researchers (of all categories above) are registered as users travelling frequently to CERN
- The rest travelling are less frequently or working in Norway within the CERN related research programmes
- The Norwegians directly paid/supported by CERN come in addition

Norway, CERN and LHC

Strong involvement in the ATLAS and ALICE experiments

ALICE:
- University of Bergen
- Bergen University College
- University of Oslo

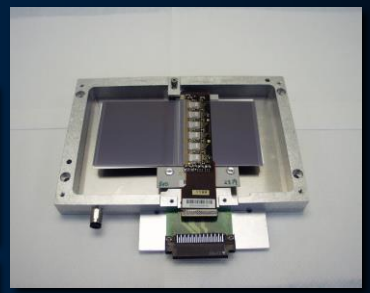
ATLAS:
- University of Bergen
- University of Oslo

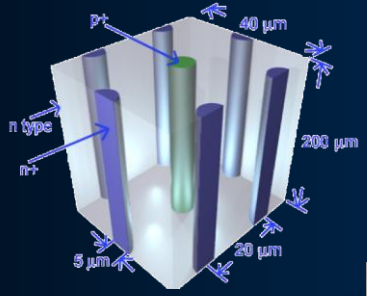
+ participation in smaller projects (CLIC, CLEAR, AWAKE, ISOLDE, AEGIS)

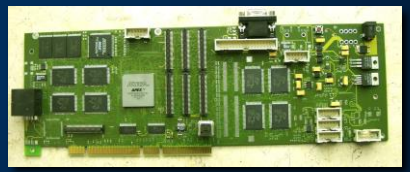
Norway and CERN

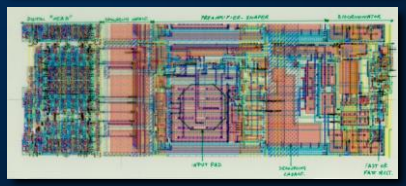
The major technology activities at CERN by Norwegian groups:

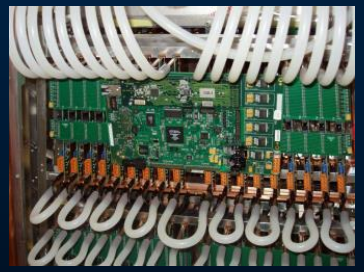
- Construction of silicon modules for ATLAS (UiB, UiO)
- PHOS detector readout for ALICE (UiB, UiO)
- High Level Trigger development for ALICE (UiB, HiB, UiO)
- Construction of cryogenics tanks for ATLAS (NTNU, UiO, Industry)
- R&D work for future detector systems and LHC upgrades (UiO, UiB, SINTEF)
- GRID development and deployment (UiO, HiB, UiB, computer centres)
- CLIC, CLEAR and AWAKE accelerator studies (UiO)



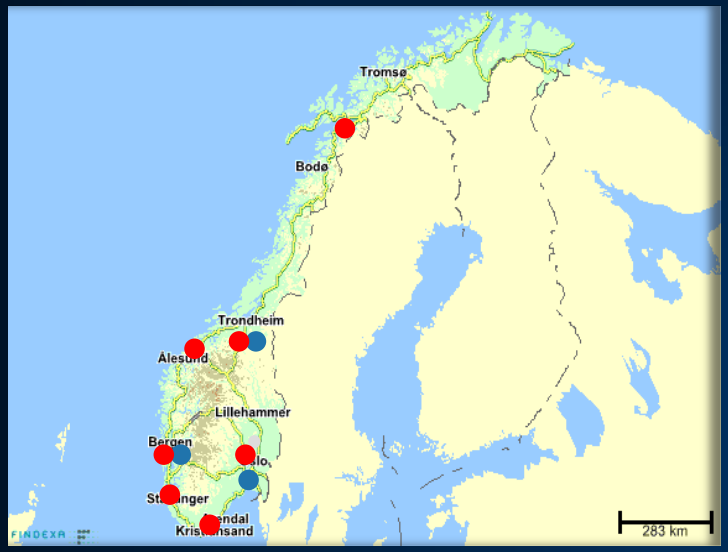








High Energy Physics in Norway



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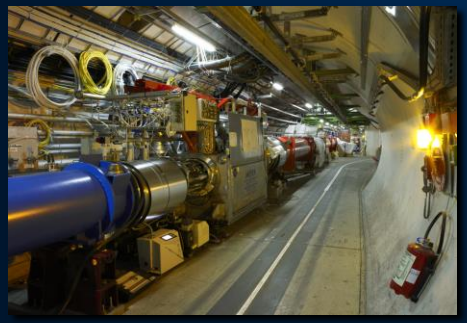
Innovation
Education
CERN
uniting people
Research

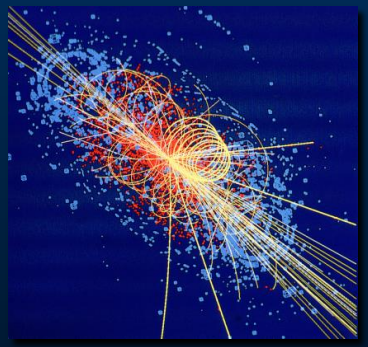
CERN: Particle Physics and Innovation

- Interfacing between fundamental science and key technological developments

- CERN Technologies and Innovation



Accelerating particle beams

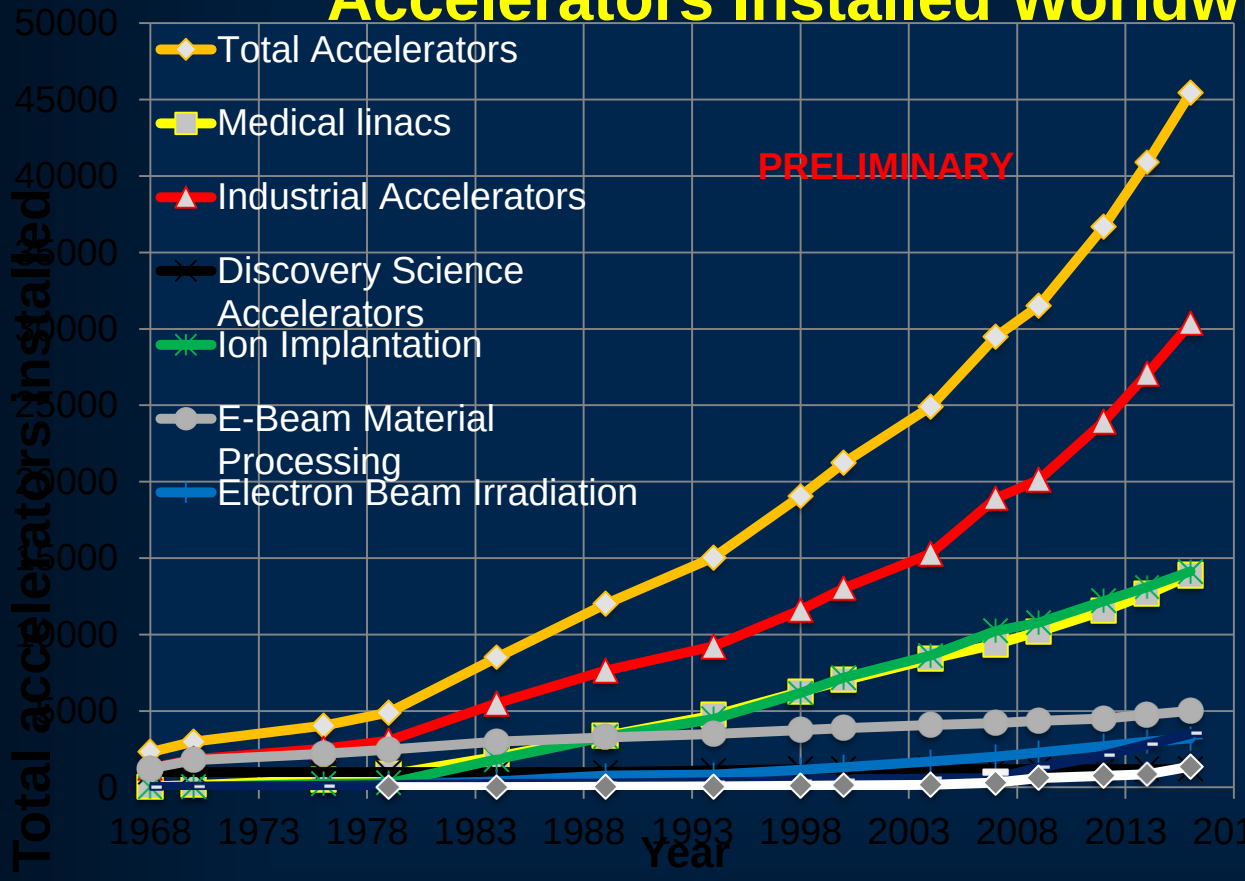


Detecting particles

Large-scale computing (Grid)

CERN

Accelerators Installed Worldwide



Total sales of accelerators is ~US$5B annually

About 47,000 systems have been sold, > 40,000 still in operation today

More than 100 vendors worldwide are in the accelerator business.

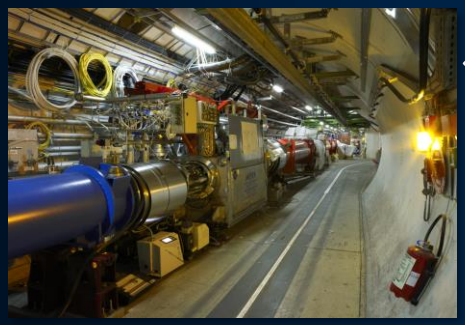
Vendors are primarily in US, Europe and Japan, but growing in China, Russia and India

R. Hamm, Accelerator-Industry Co-Innovation Workshop, Feb 6, 2018, Brussels, Belgium

CERN

Medical Application as an Example of Particle Physics Spin-off

Combining Physics, ICT, Biology and Medicine to fight cancer

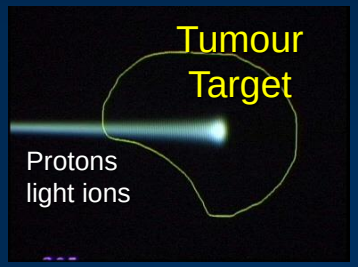


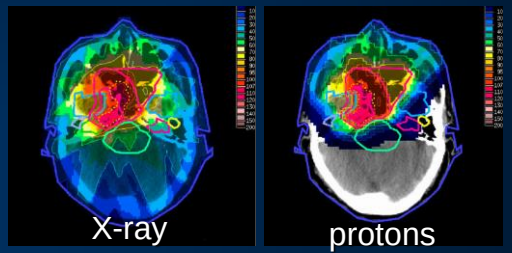
Accelerating particle beams

~40’000 accelerators worldwide

~1/3 of them used for medicine

Hadron Therapy

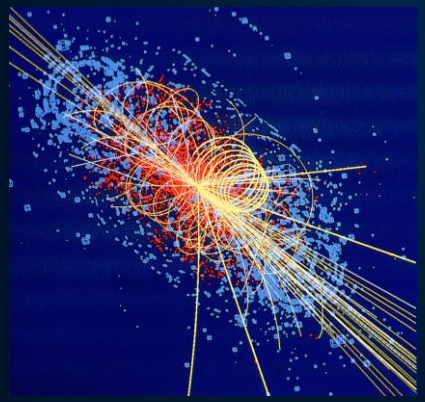




Leadership in Ion Beam Therapy now in Europe and Japan

>100’000 patients treated worldwide (45 facilities)

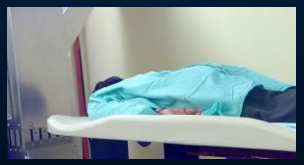
>50’000 patients treated in Europe (14 facilities)



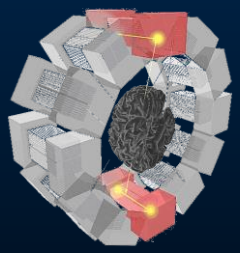
Detecting particles

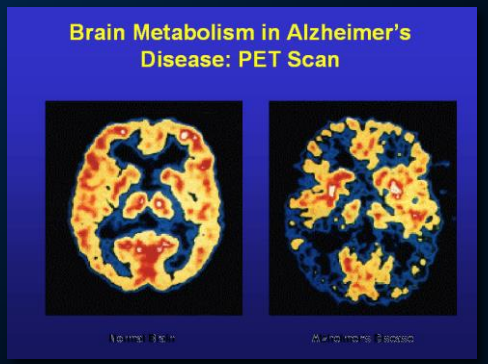
Imaging

Clinical trial in Portugal, France and Italy for new breast imaging system (ClearPEM)



PET Scanner



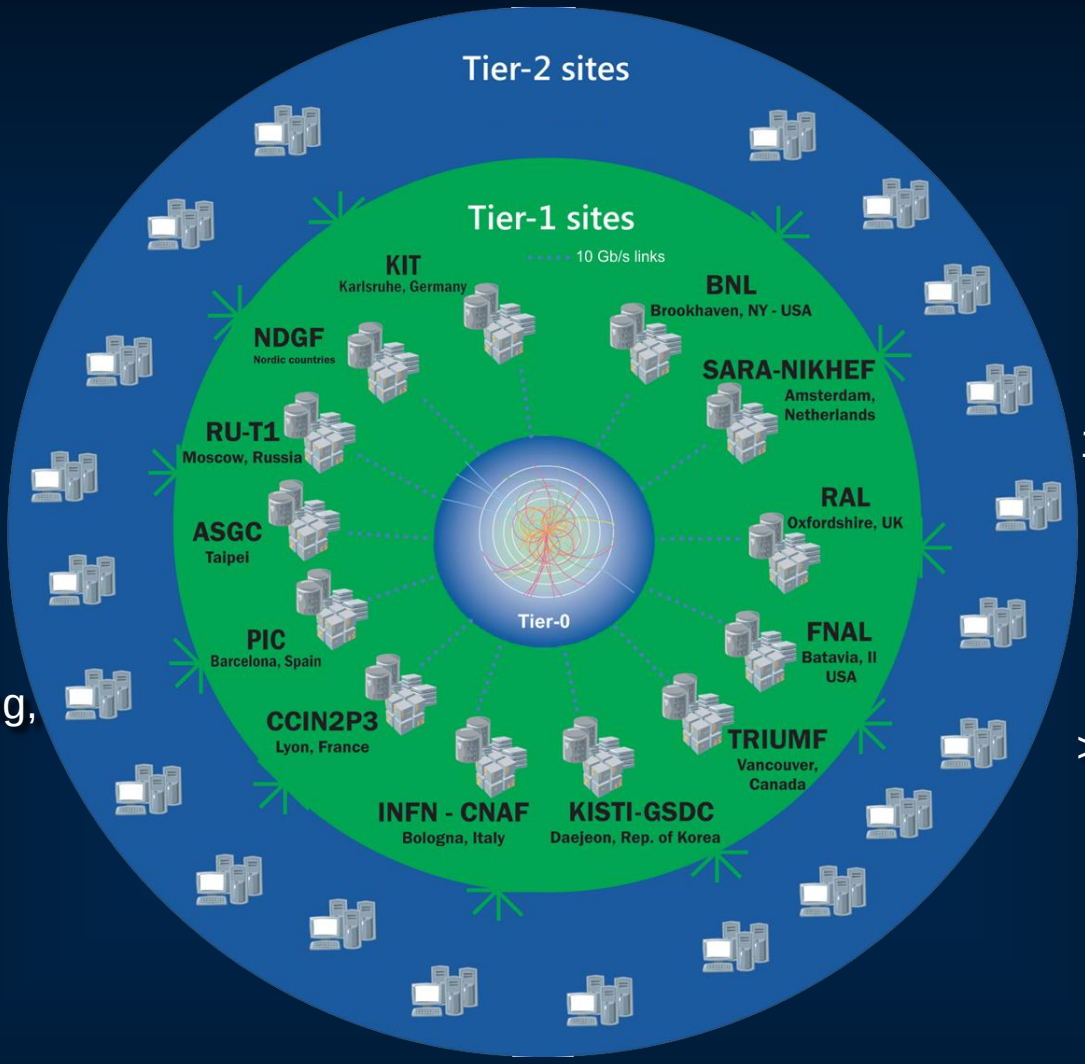


The Worldwide LHC Computing Grid

Tier-0 (CERN): data recording, reconstruction and distribution

Tier-1: permanent storage, reprocessing, analysis

Tier-2: simulation, end-user analysis



~ 170 sites in > 40 countries

1 million CPU cores

1000 PB of storage

> 2 million jobs/day

50 GB/s global transfers

WLCG:
An International collaboration to distribute and analyse LHC data

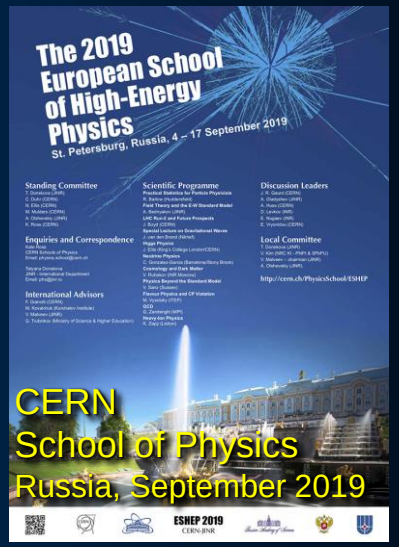
Integrates computer centres worldwide that provide computing and storage resource into a single infrastructure accessible by all LHC physicists

CERN

CERN Education Activities

Scientists at CERN
Academic Training Programme

Young Researchers
CERN School of High Energy Physics
CERN School of Computing
CERN Accelerator School



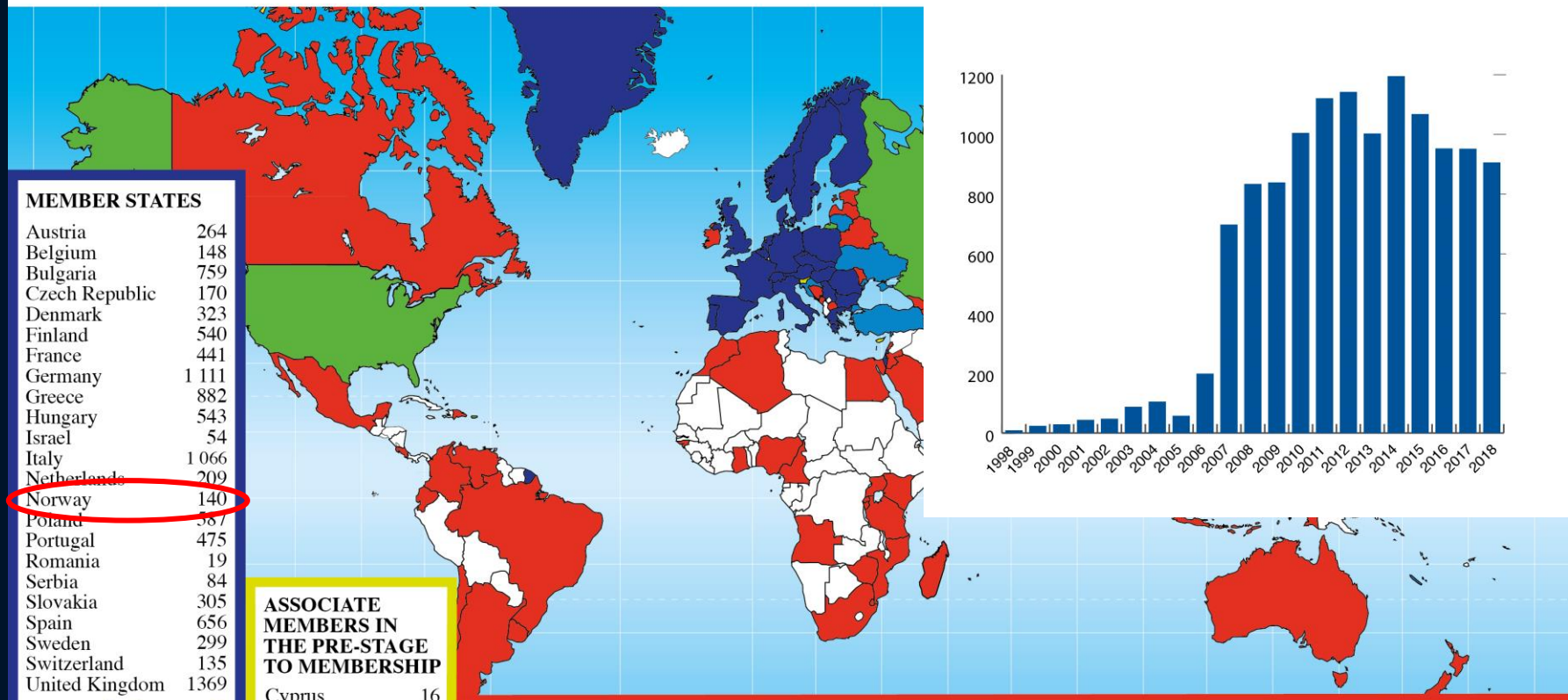
Undergraduates
Summer Students Programme

CERN Teacher Schools
International and National Programmes

Public visitors
150 thousand per year

CERN Teacher Programme

Teacher Programme Participants 1998 - 2019 (Total: 13 224)



MEMBER STATES

Austria	264
Belgium	148
Bulgaria	759
Czech Republic	170
Denmark	323
Finland	540
France	441
Germany	1 111
Greece	882
Hungary	543
Israel	54
Italy	1 066
Netherlands	209
Norway	140
Poland	387
Portugal	475
Romania	19
Serbia	84
Slovakia	305
Spain	656
Sweden	299
Switzerland	135
United Kingdom	1369

10 579

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP

Cyprus	16
Slovenia	44

60

ASSOCIATE MEMBERS

Croatia	113
India	12
Lithuania	64
Pakistan	9
Turkey	364
Ukraine	206

768

OBSERVERS

Japan	12
Russia	431
USA	126

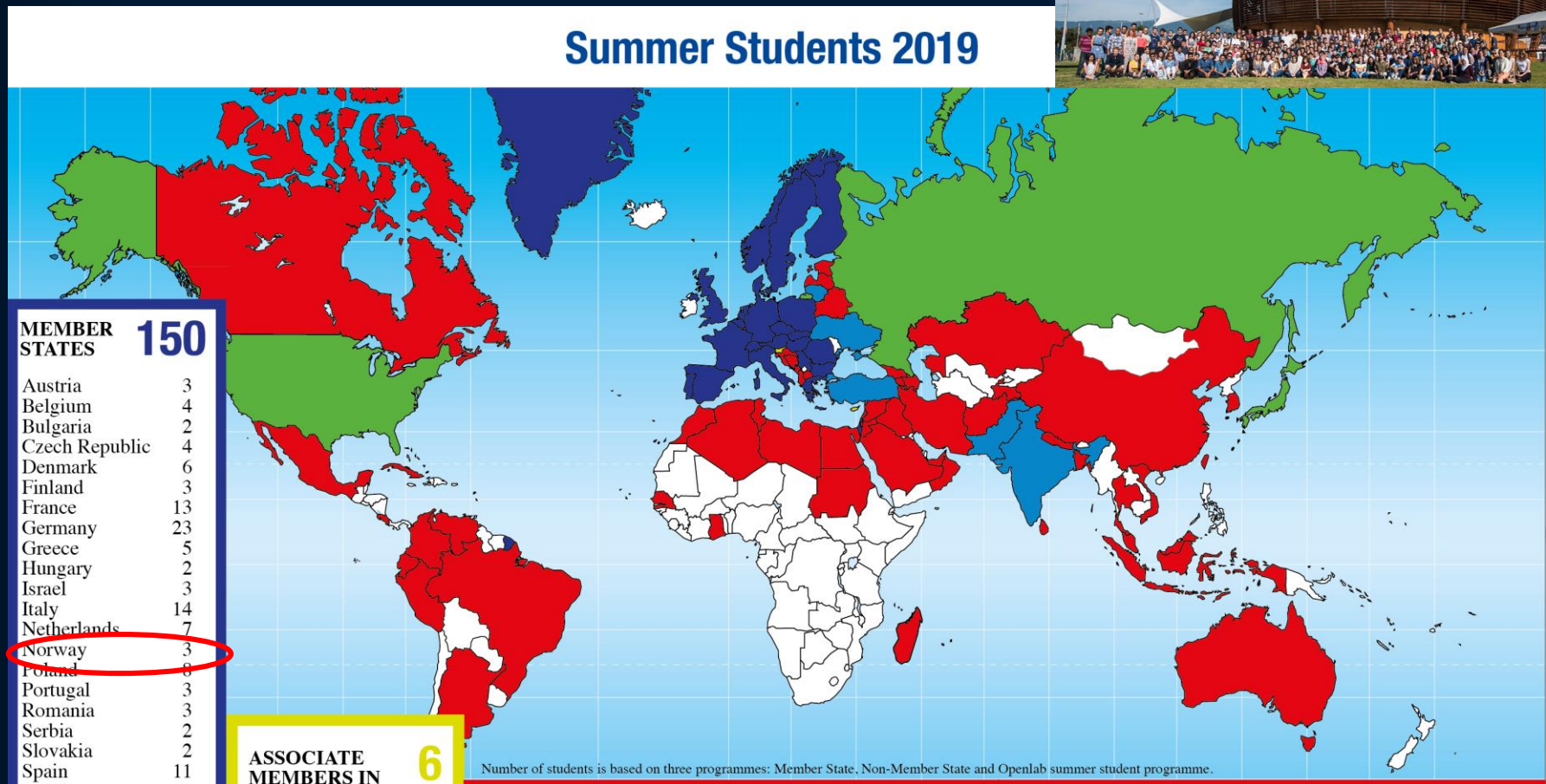
569

OTHERS

Algeria	11	Brazil	252	Estonia	105	Kuwait	1	Nepal	4	Sri Lanka	3
Angola	9	Burundi	2	Eswatini	1	Latvia	76	New Zealand	4	Taiwan	1
Argentina	3	Cameroon	9	Georgia	173	Lebanon	21	Nigeria	2	Tanzania	1
Armenia	3	Canada	17	Ghana	7	Madagascar	2	North Macedonia	13	Thailand	21
Australia	12	Cape Verde	4	Guinea Bissau	1	Malaysia	1	Palestine	5	Timor-Leste	9
Azerbaijan	2	Chile	4	Indonesia	3	Malta	51	Philippines	3	Uganda	3
Bahrain	3	China	3	Iran	13	Mexico	96	Qatar	1	U.A.E.	1
Bangladesh	1	Colombia	7	Ireland	9	Moldova	4	Rwanda	20	Uruguay	3
Belarus	11	Costa Rica	4	Jordan	13	Mongolia	1	Sao Tome	7	Venezuela	1
Bosnia and Herzegovina	11	Dominican Rep.	73	Kazakhstan	14	Montenegro	16	Saudi Arabia	1	Vietnam	2
		Ecuador	2	Kenya	4	Morocco	2	Singapore	2	Zimbabwe	1
		Egypt	3	Korea	49	Mozambique	22	South Africa	9		

1 248

Summer Students 2019



MEMBER STATES 150

Austria	3
Belgium	4
Bulgaria	2
Czech Republic	4
Denmark	6
Finland	3
France	13
Germany	23
Greece	5
Hungary	2
Israel	3
Italy	14
Netherlands	7
Norway	3
Poland	8
Portugal	3
Romania	3
Serbia	2
Slovakia	2
Spain	11
Sweden	7
Switzerland	5
United Kingdom	17

ASSOCIATE MEMBERS 24

India	13
Lithuania	2
Pakistan	4
Turkey	3
Ukraine	2

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP 6

Cyprus	4
Slovenia	2

OBSERVERS 34

Japan	4
Russia	10
USA	20

OTHERS

Afghanistan	1	Bolivia	1	Egypt	4	Kuwait	1	Nepal	1	Tajikistan	1
Albania	1	Bosnia & Herzegovina	1	Estonia	2	Latvia	1	North Macedonia	1	Thailand	4
Algeria	4	Brazil	4	Georgia	1	Lebanon	3	Oman	1	Tunisia	2
Argentina	1	Canada	6	Ghana	1	Libya	1	Palestine	2	U.A.E.	1
Armenia	1	Chile	1	Hong Kong	2	Madagascar	1	Peru	1	Venezuela	1
Australia	1	China	10	Indonesia	1	Malaysia	3	Saudi Arabia	1	Viet Nam	1
Azerbaijan	2	Colombia	1	Iran	2	Malta	3	Singapore	2	Yemen	1
Bahrain	2	Costa Rica	4	Iraq	1	Mauritius	1	Sri Lanka	4		
Bangladesh	2	Croatia	4	Jordan	1	Mexico	1	Sudan	1		
Belarus	1	Cuba	2	Kazakhstan	3	Moldova	1	Syrian Arab Republic	1		
		Ecuador	3	Korea	2	Montenegro	4				
				Kosovo	1	Morocco	1	Taiwan	1		

122

TTE programme

SMP - 12.04.14.

FORSKING: Forskingsstasjonen i CERN består mellom anna av ein tre mil lang underjordisk aksellerator som der ein kan prøve ut fysiske teoriar. Lektor Arne Terje Pettersen (tv) ved Haram vg. skole har forska der, og no misunner han ungguten Arne Sigvard Steen (th) som får seg minst eitt år ved det prestisjefylte senteret.

Drømmejobb i CERN

• Arne Sigvard Steen (18) til stort f

BRATTVÅG

Arne Sigvard Steen (18) frå Haramsøya blir den første ungdommen frå Norge som får arbeide ved det prestisjefylte forskingssenteret CERN i Sveits.

– Eg hadde aldri trudd at det var mogleg for meg å få ein slik jobb, seier den unge eleven ved Haram vidaregåande skule.

CERN ligg ved Geneve, og tar kvart år inn ei handfull unge trainee frå heile verda for at dei skal bli kjent med det som går føre seg i senteret. At ein ungdom frå Norge får vere med, er oppsiktsvekkjande.

– Eg har alltid interessert meg for realfag. Då læraren min Terje Pettersen oppmoda meg om å søkje, ville eg prøve. Dette blir spanande, seier Arne Sigvard og smilar breitt. Han tek til etter sommarferien, og er han flink nok kan han få vere der i to år.

Forskar ved Cern. Terje Pettersen, som, har vore lærar ved Haram vidaregåande skule sidan 1996, har høg forskarutdanning og har ei tid arbeidd ved CERN. Sidan 2008 har han tatt med elevar frå skulen for å gjere dei kjent med senteret.

BAKGRUNN

- CERN er ein internasjonal organisasjon for partikkelfysisk forsking og omfattar verdas største forskingssenter innan dette faget.
- Senteret ligg hovudsakleg i Sveits og har ein enorm partikkelakselerator som blei tatt i bruk til vitskaplege eksperiment i 2008.
- CERN blei etablert i 1954 og har i dag 20 medlemsland, rundt 2600 heiltidstilsette pluss nesten 8000 vitskapsfolk og ingeniørar.

– Eg skal setje saman magnetar i akseleratoren, som går i sirkel under byen

ARNE SIGVARD STEEN

TREINE
utan ak
Sveits i

Han va
guten
– Eg er
vard, o
Petters
frå Ørs

Fagbre
kome
har fag
noko
ein sjø
Arne
avslut
TAF-li
og ser
ning i
praksi
våg, o
CERN

Innmørsposten
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smp.no

Ei lita brikke i det store

• Pål Forr Austnes frå Haramsøya jobbar hos Cern

CERN

Ein 27 kilometer lang tunnel med partiklar tilsvarande energien til over 2.000 lyntog i 300 km/t. Som teknikar på verdas største forskingssenter bør ein helst ikkje tenkje for mykje på dei enorme kreftene som er i sving.

–Ein føler seg som ei lita brikke i det heile, seier Pål Forr Austnes (21). Til trass for kor lita brikke han er, så er han like fullt ein del av eit større maskineri som gjer nytte for seg og får høve til å gi noko tilbake.

Rett på. Som ein av dei yngste på si avdeling byrja haramsøyingen i jobben som teknikar på forskingssenteret i juni. Han

FAKTA

- Den europeiske organisasjonen for kjernefysisk forsking (Cern) vart etablert i 1954.
- Organisasjonen har i dag 20 medlemsland, 2.600 heiltidstilsette, pluss nesten 8.000 vitskapsfolk og ingeniørar frå heile verda.
- Verdas største partikkelakeselerator (Large Hadron Collider) er på senteret til Cern, utanfor Genève, og blir brukt til vitskaplege eksperiment.
- Cern la også grunnlaget for World Wide Web.

– Ein føler seg som ei lita brikke, men samstundes får ein vere med på å gi noko tilbake

PÅL FORR AUSTNES (21)

YNGSTE: Pål Forr Austnes (21) frå Haramsøya jobbar som teknikar i Cern, og er ein av dei yngste på si avdeling. FOTO: PRIVAT

Big Bang. Forenkla forklart har Austnes ansvar for å halde i gang og utvikle maskiner som fysikarane nyttar til sine eksperiment. Deriblant verdas største partikkelakselerator. Når protonar kolliderer i ei voldsom fart, tett oppunder lysets hastigheit, har det mellom anna blitt oppdaga nye partiklar som kan gi større forståing for første augneblinka i universets utvikling.

– Eg har kun fysikk frå vidaregåande nivå, så dette vert for høgtsvevande for meg, seier Austnes. For å forstå dei enorme kreftene, kan ein samanlikne det med følgjande: Når partikkelakseleratoren går for full maskin, tilsvarer det energien til over 2.000 lyntog som køyrer i 300 km/t.

– Vert du litt audmjuk av å jobbe på Cern?

– Ja, det må ein vere. Men det går veldig fint. Alle er inklude-

UiA

- Have used and continue to use Technical Student programme (individuals or strategic)
- Now member of the CMS collaboration – identify key areas of collaboration


LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km
Thank you!
Mange takk!
CERN
Accelerating Science and Innovation

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