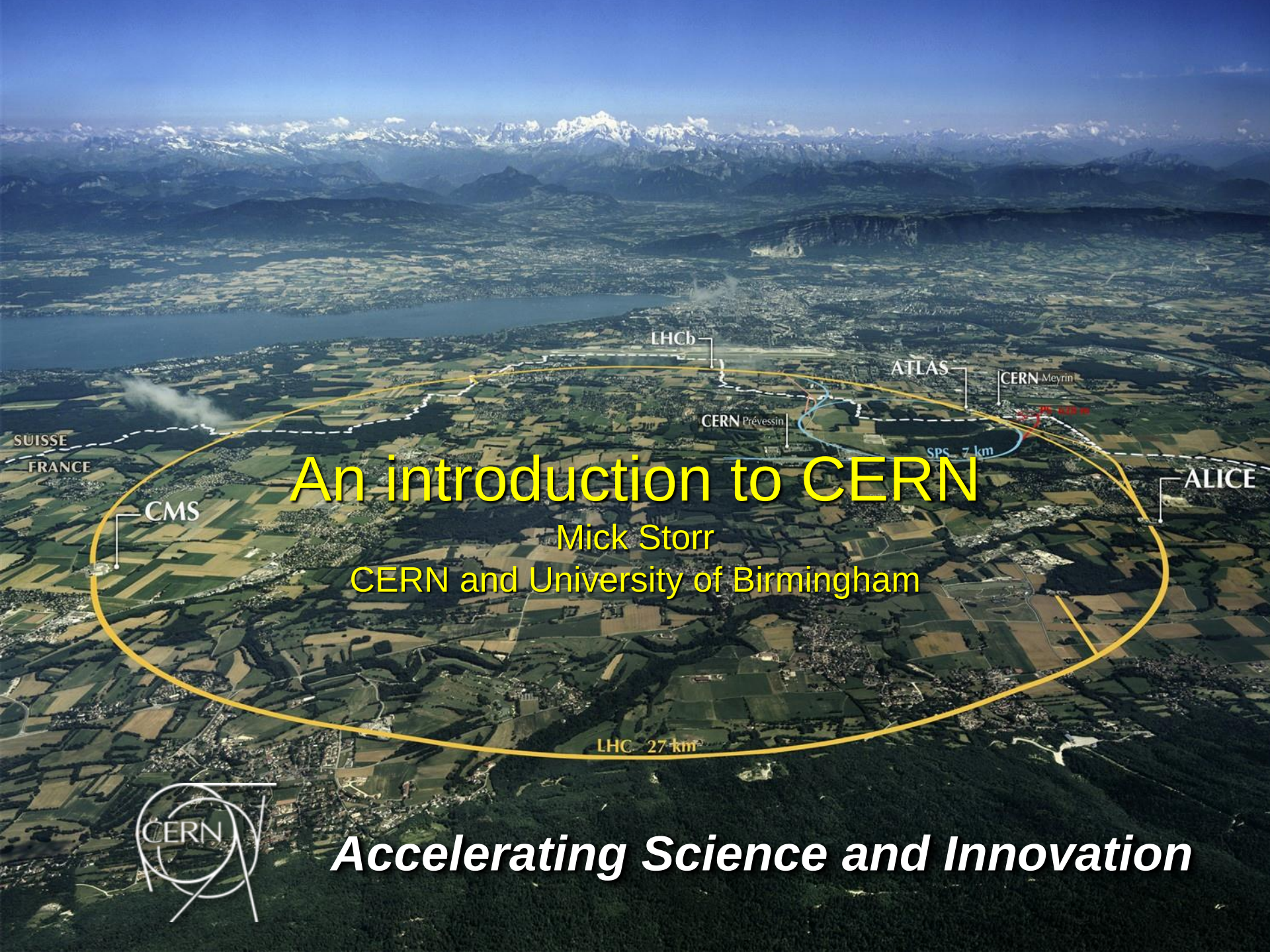


An introduction to CERN

Mick Storr
CERN and University of Birmingham

Accelerating Science and Innovation

1945 l'Europe après deux guerres dévastatrices en moins de 30 ans

Les chercheurs quittent l'Europe pour USA

CERN: founded in 1954: 12 European States
"Science for Peace"
Today: 22 Member States

~ 2'500 staff
~ 1'800 other paid personnel
~ 13'000 scientific users

Budget (2017) ~ 1'100 MCHF

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

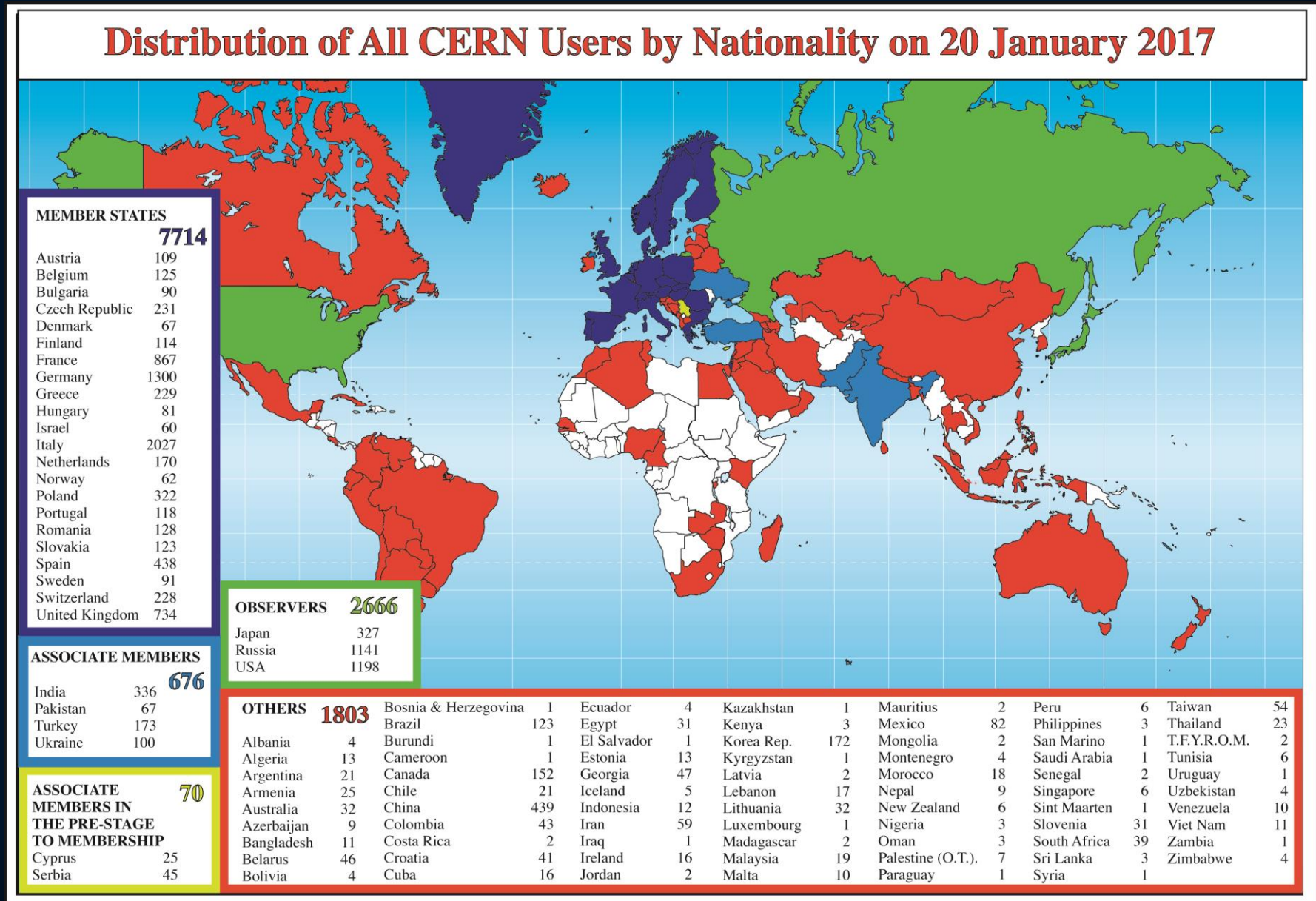
Associate Member States: India, Pakistan, Turkey, Ukraine

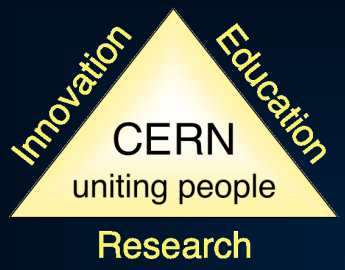
Associate Members in the Pre-Stage to Membership: Cyprus, Serbia

Applications for Membership or Associate Membership: Brazil, Croatia, Lithuania, Russia, Slovenia

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

Science is getting more and more global

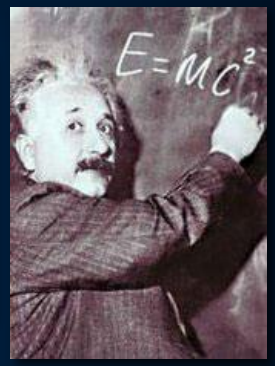




The Mission of CERN

- **Push forward** the frontiers of knowledge

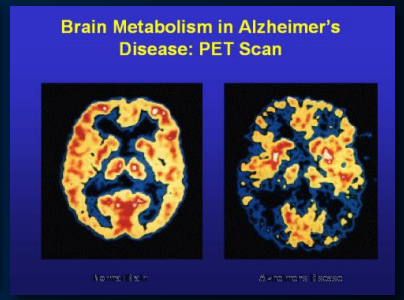
  E.g. the secrets of the Big Bang … what was the matter like within the first moments of the Universe's existence?

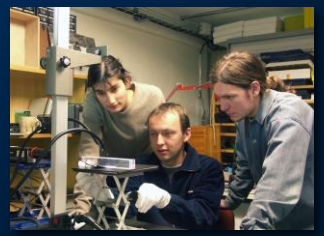


- **Develop** new technologies for accelerators and detectors

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy

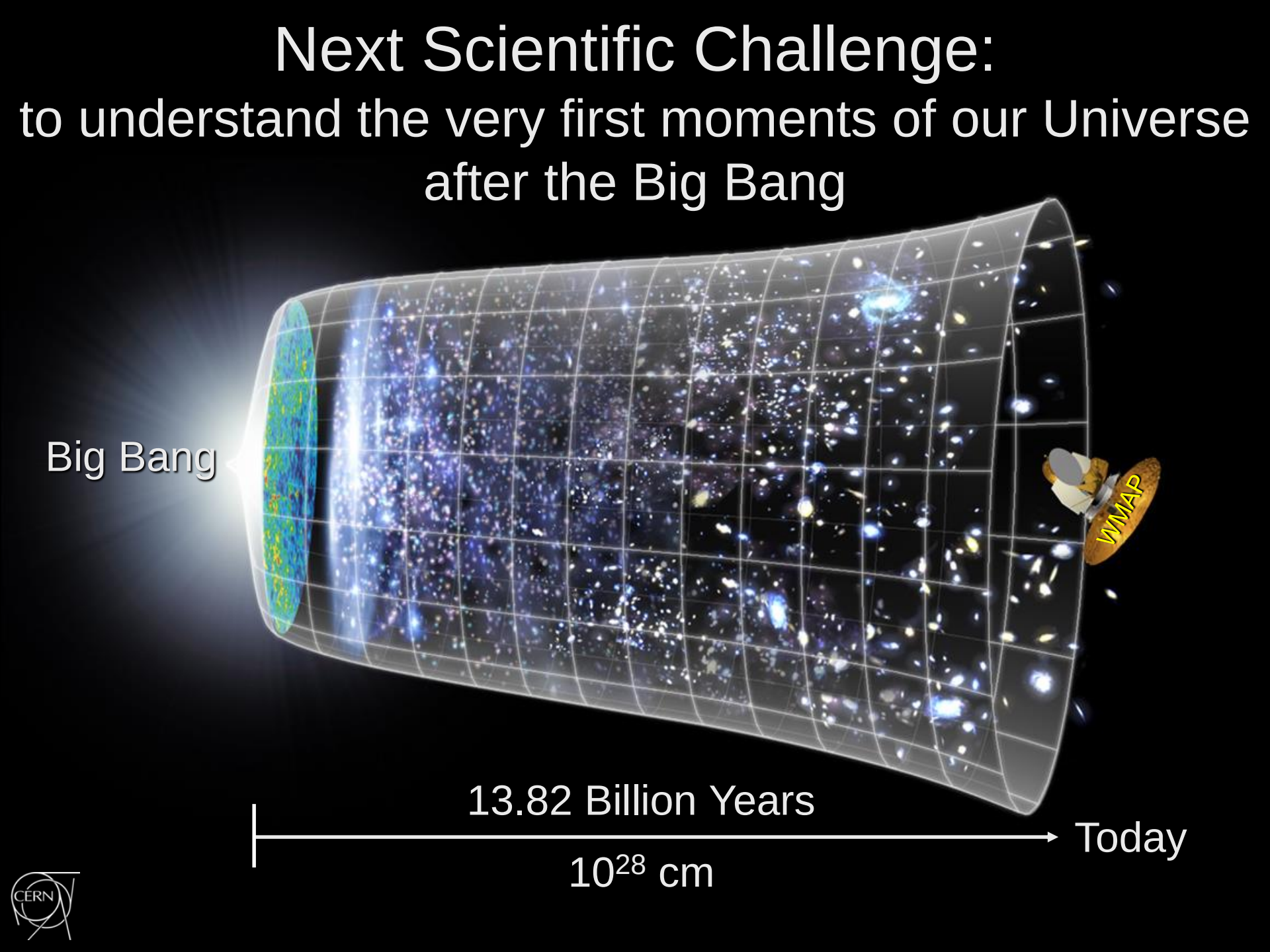


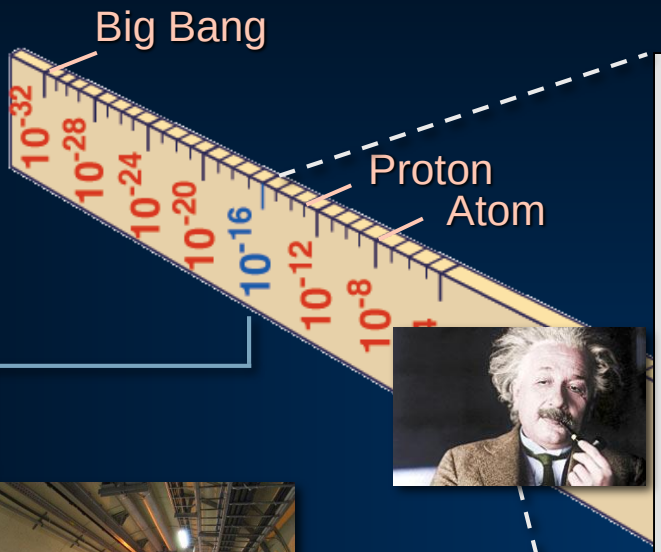


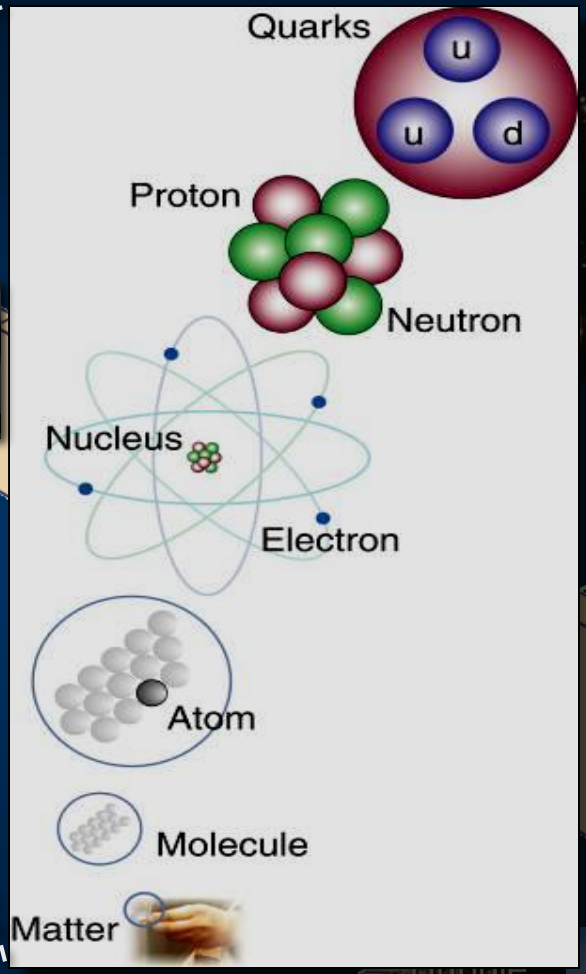
- **Train** scientists and engineers of tomorrow

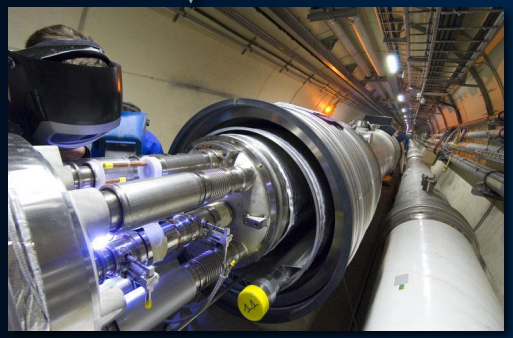
- **Unite** people from different countries and cultures

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



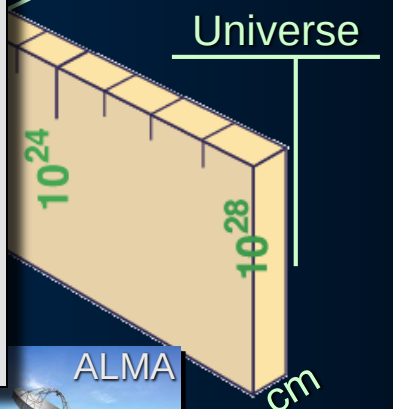


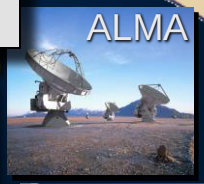


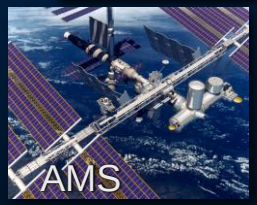


LHC

Super-Microscope

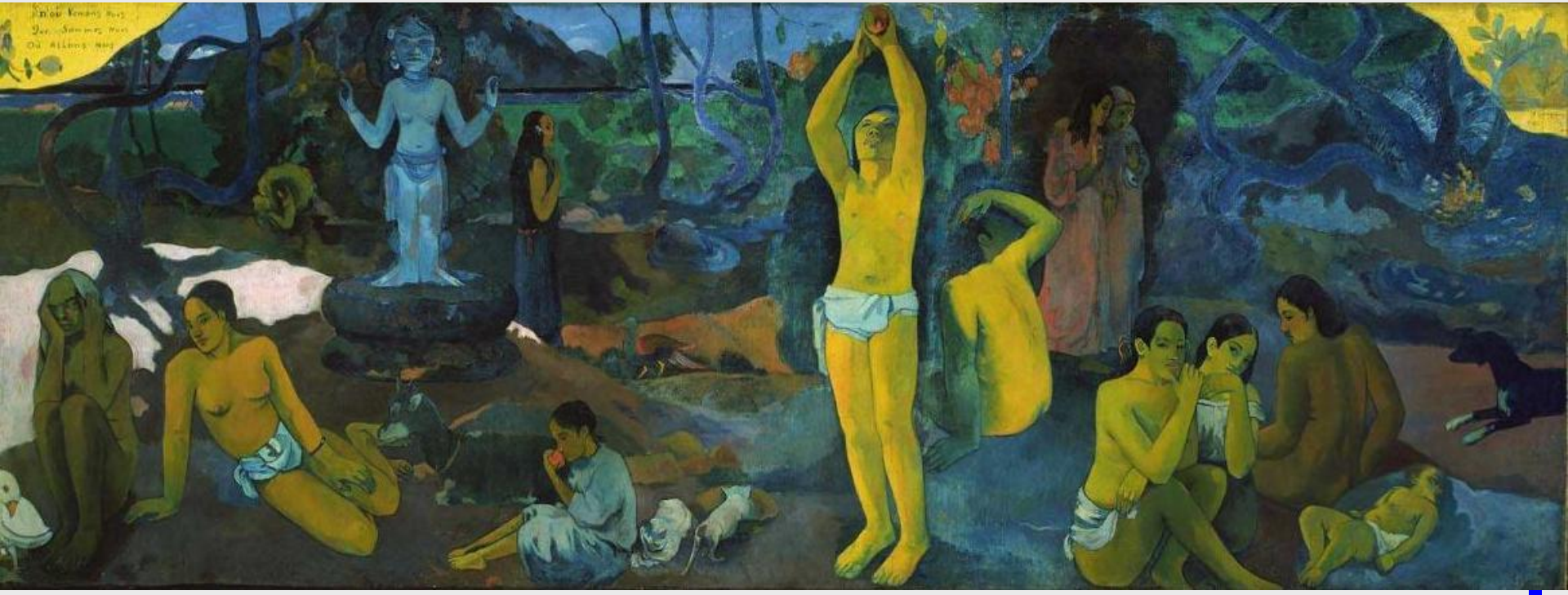






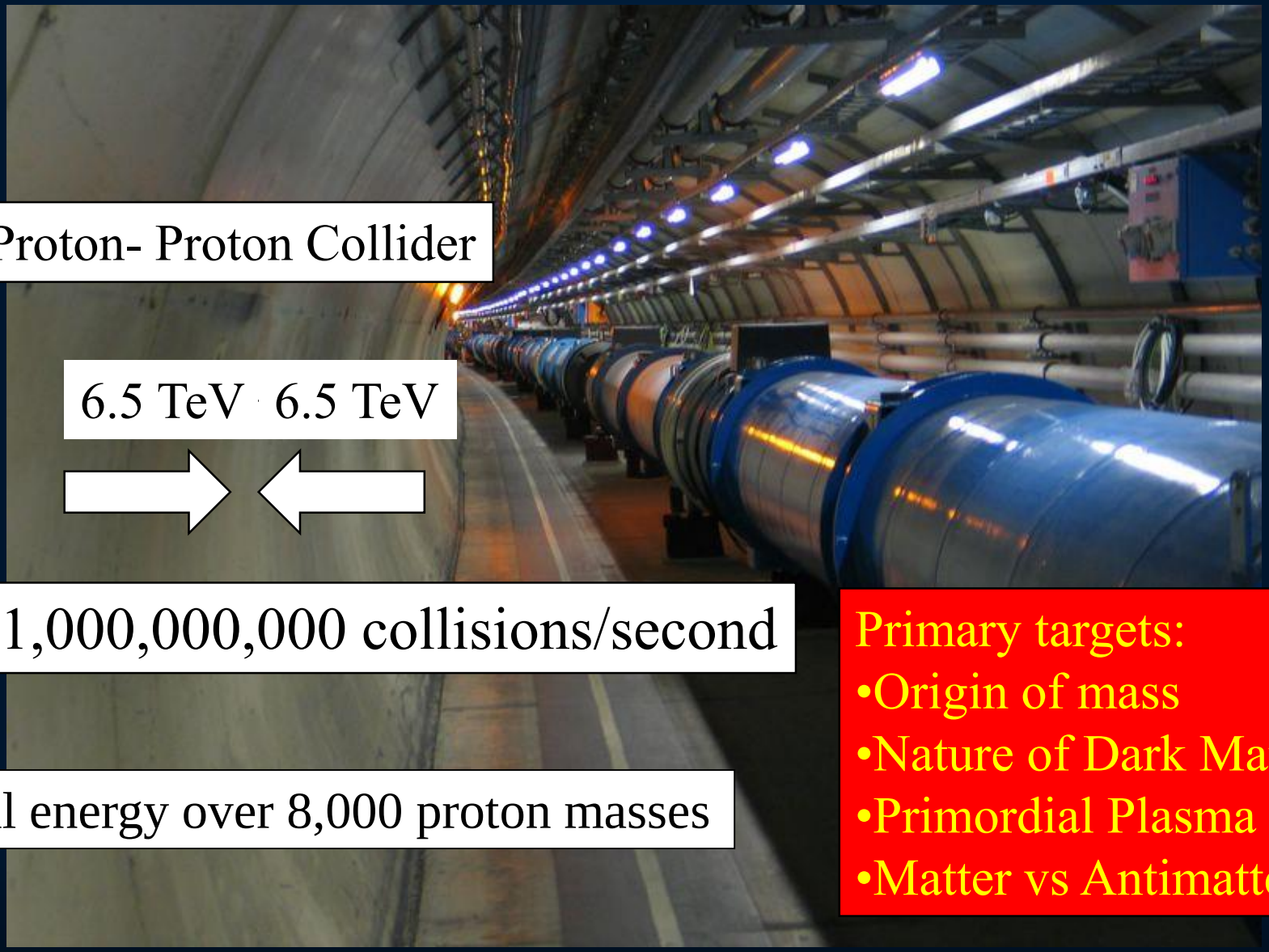
Study physics laws of first moments after Big Bang
increasing Symbiosis between Particle Physics,
Astrophysics and Cosmology

“Where do we come from?
What are we?
Where are we going?”



The aim of particle physics, CERN & the LHC:
What is the Universe made of?

The Large Hadron Collider (LHC)



Proton- Proton Collider

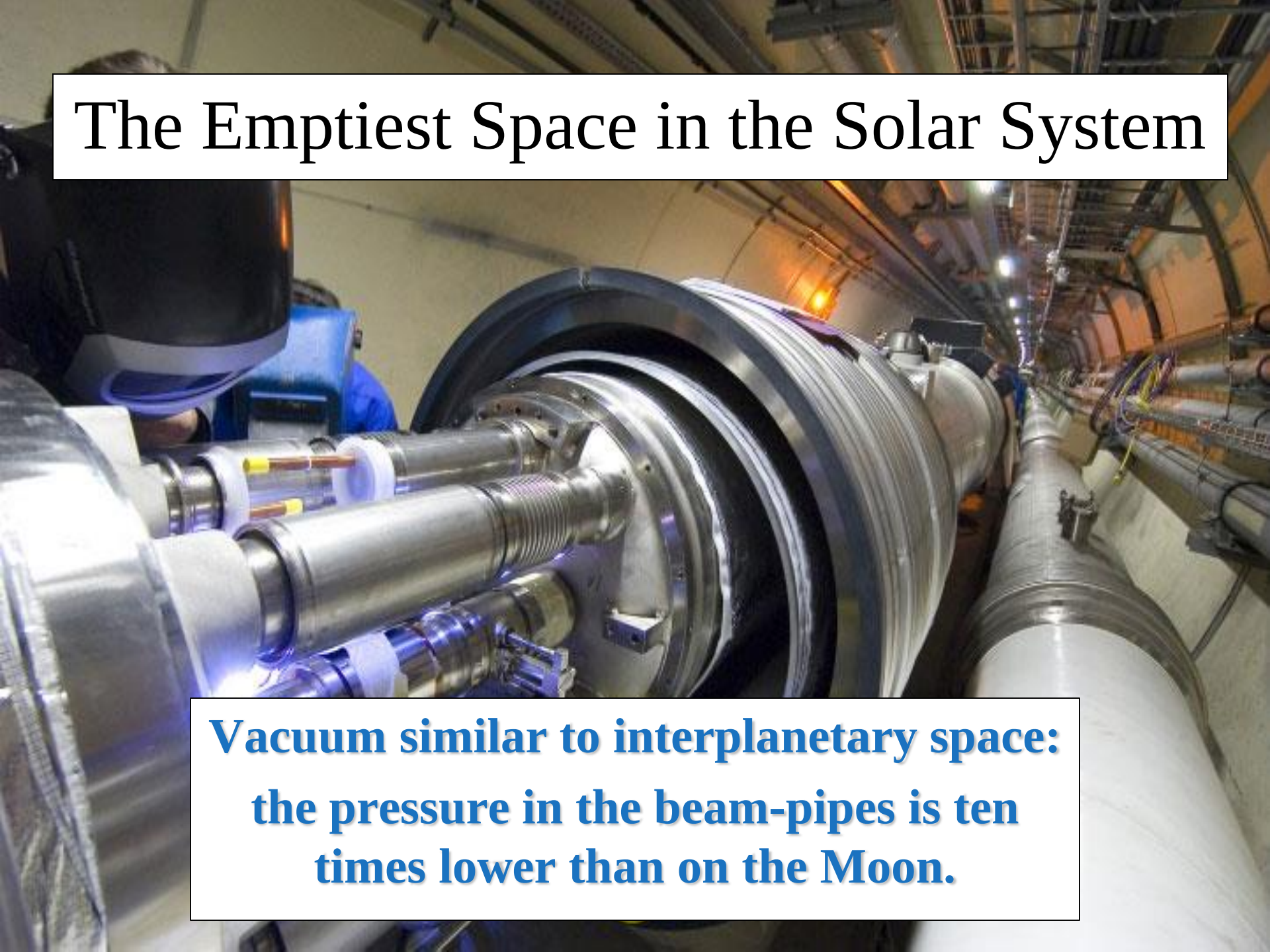
6.5 TeV 6.5 TeV

1,000,000,000 collisions/second

Total energy over 8,000 proton masses

Primary targets:
- Origin of mass
- Nature of Dark Matter
- Primordial Plasma
- Matter vs Antimatter

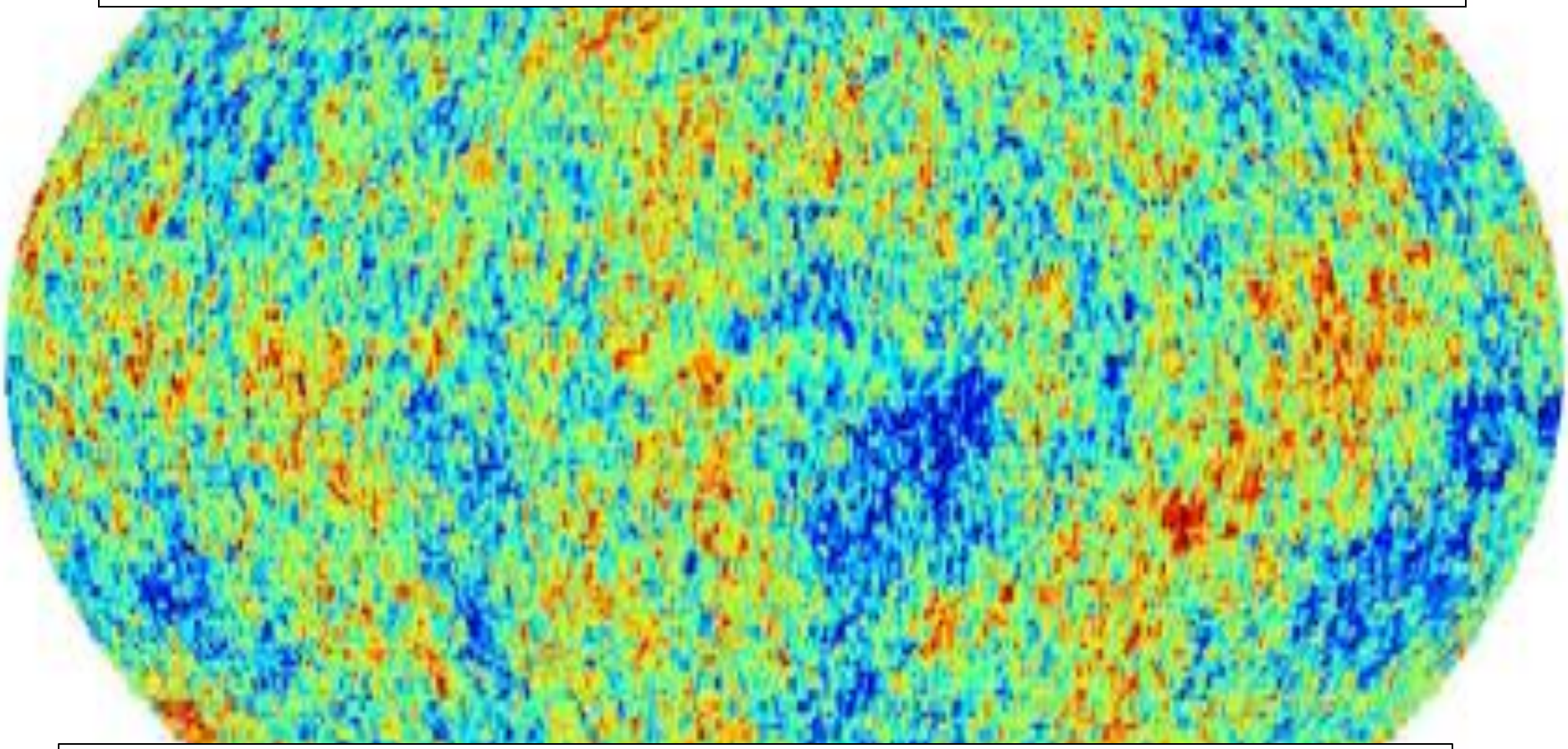
The Emptiest Space in the Solar System



Vacuum similar to interplanetary space:

the pressure in the beam-pipes is ten times lower than on the Moon.

Colder than Outer Space

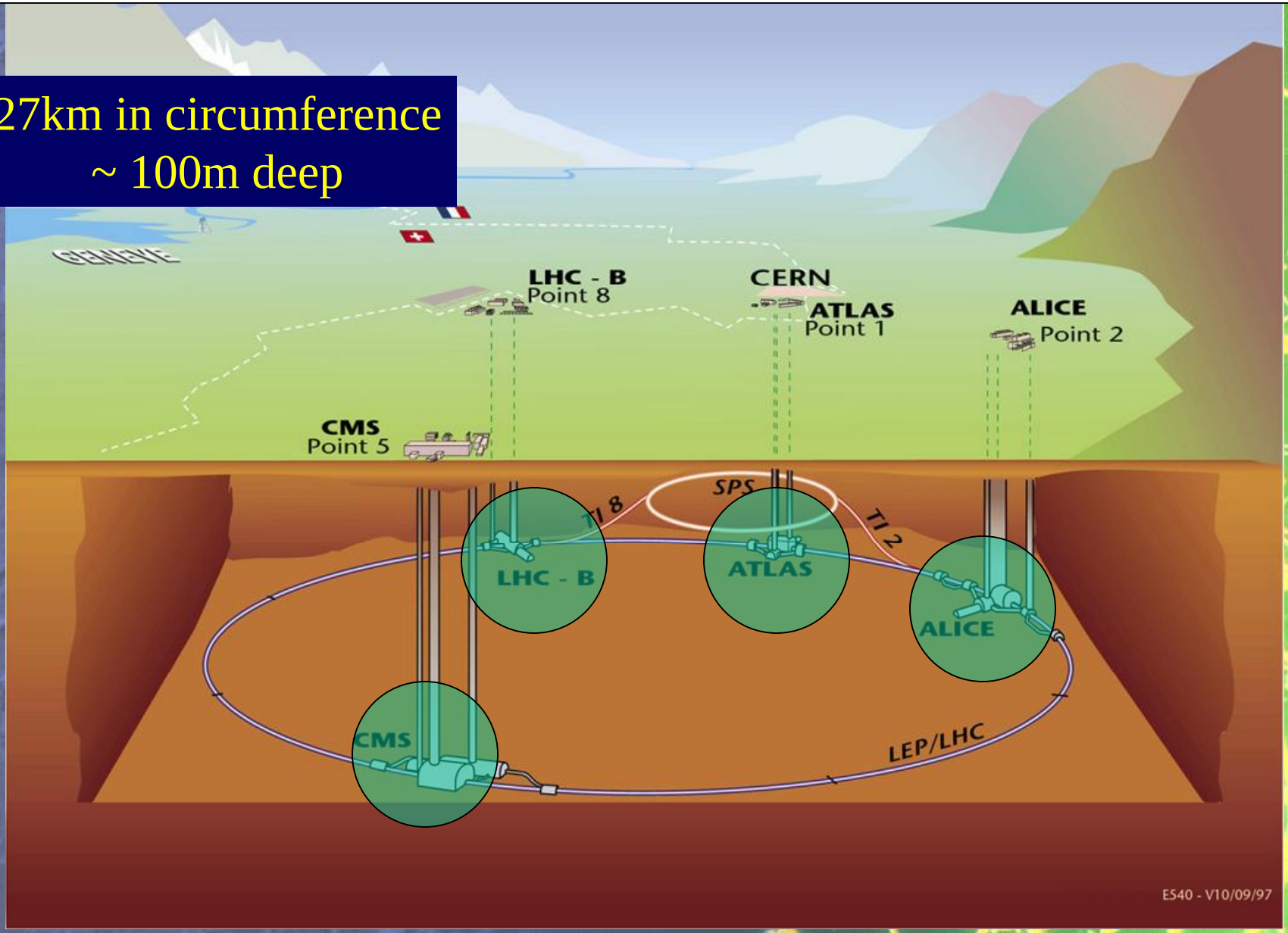


LHC 1.9 degrees above absolute zero = - 271 C

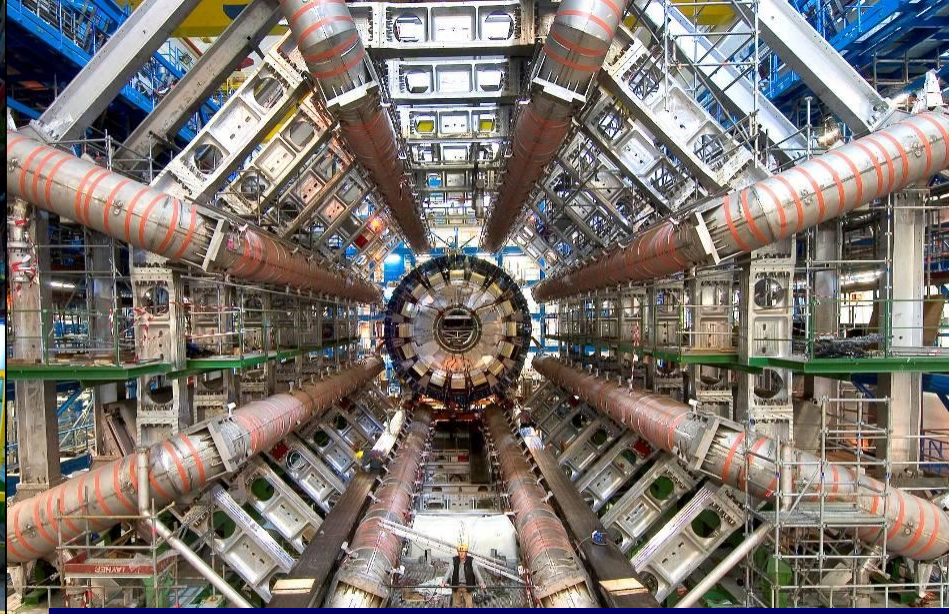
Outer space 2.7 degrees above zero = - 270 C

General View of LHC & its Experiments

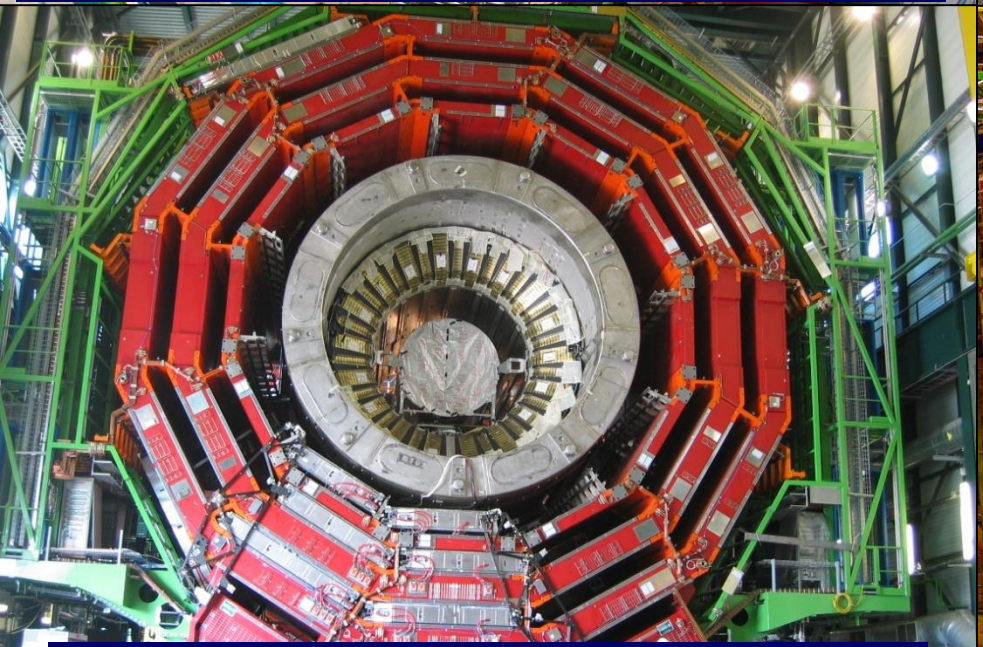
27km in circumference
~ 100m deep



ALICE: Primordial cosmic plasma



ATLAS: Higgs and supersymmetry

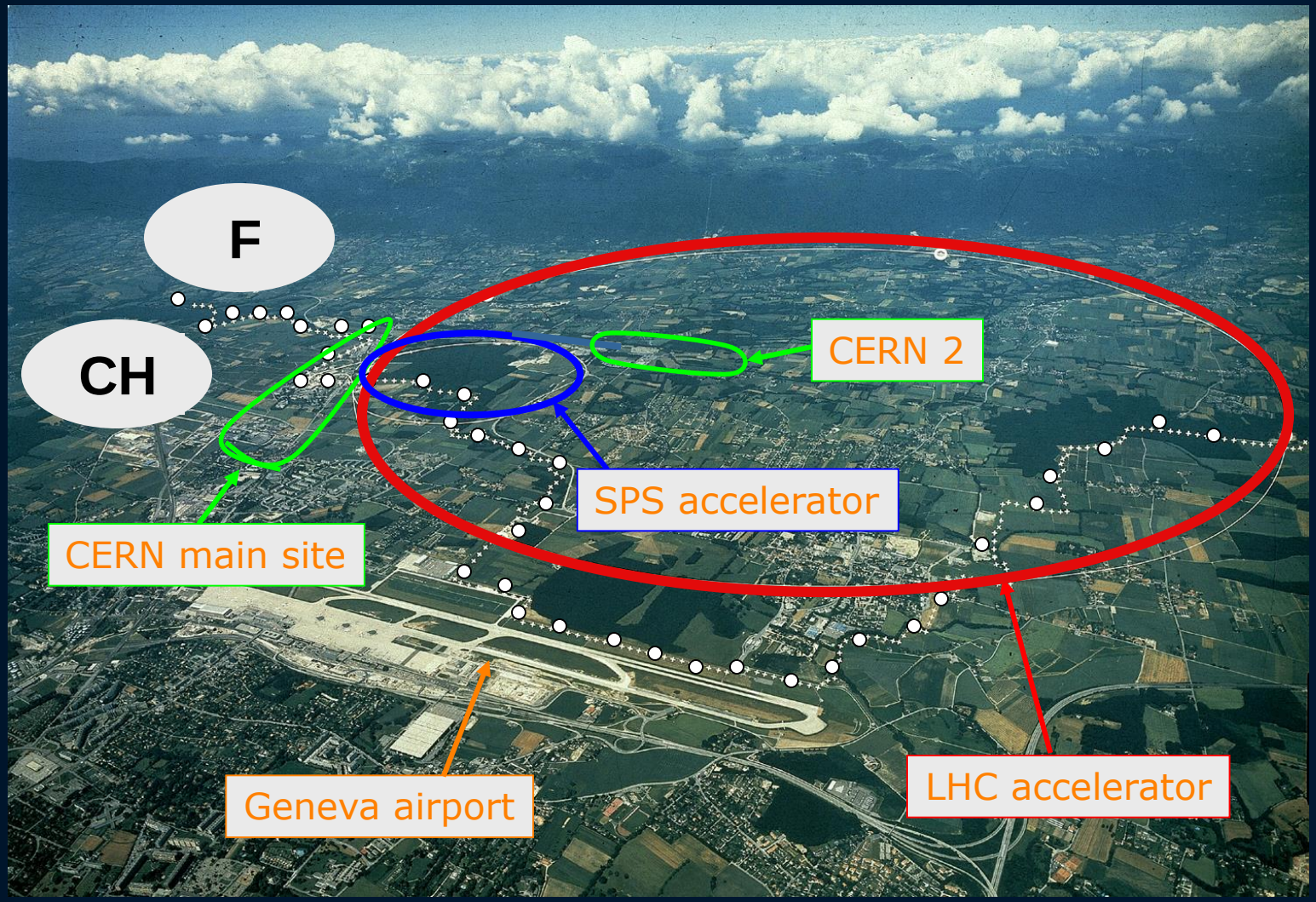


CMS: Higgs and supersymmetry

LHCb: Matter-antimatter differenc

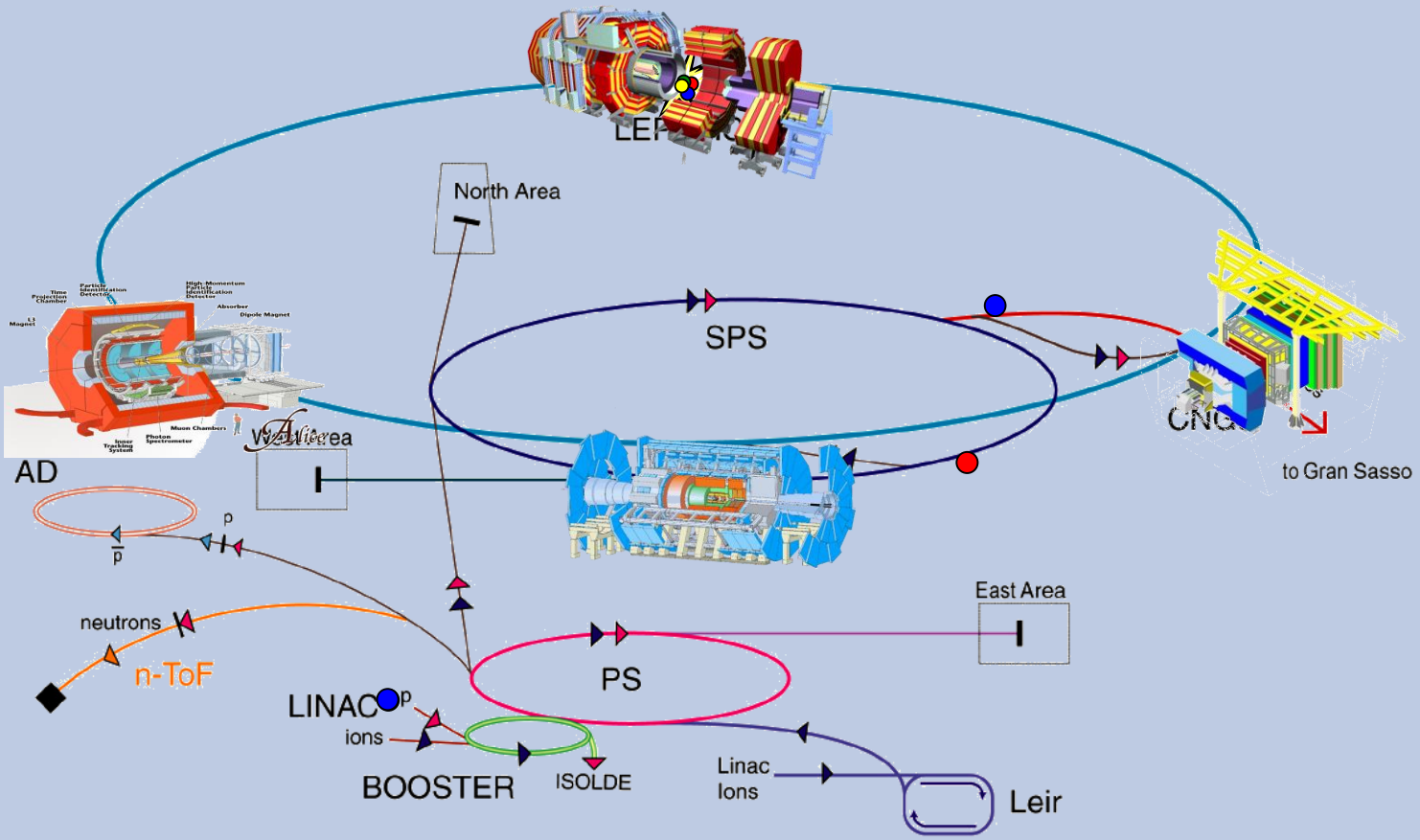
The Hottest Place in the Galaxy

Particle collisions create (within a tiny volume) temperatures a billion times higher than in the heart of the Sun


F
CH
CERN 2
SPS accelerator
CERN main site
Geneva airport
LHC accelerator

Large Hadron Collider

Collision of proton beams… …observed in giant detectors

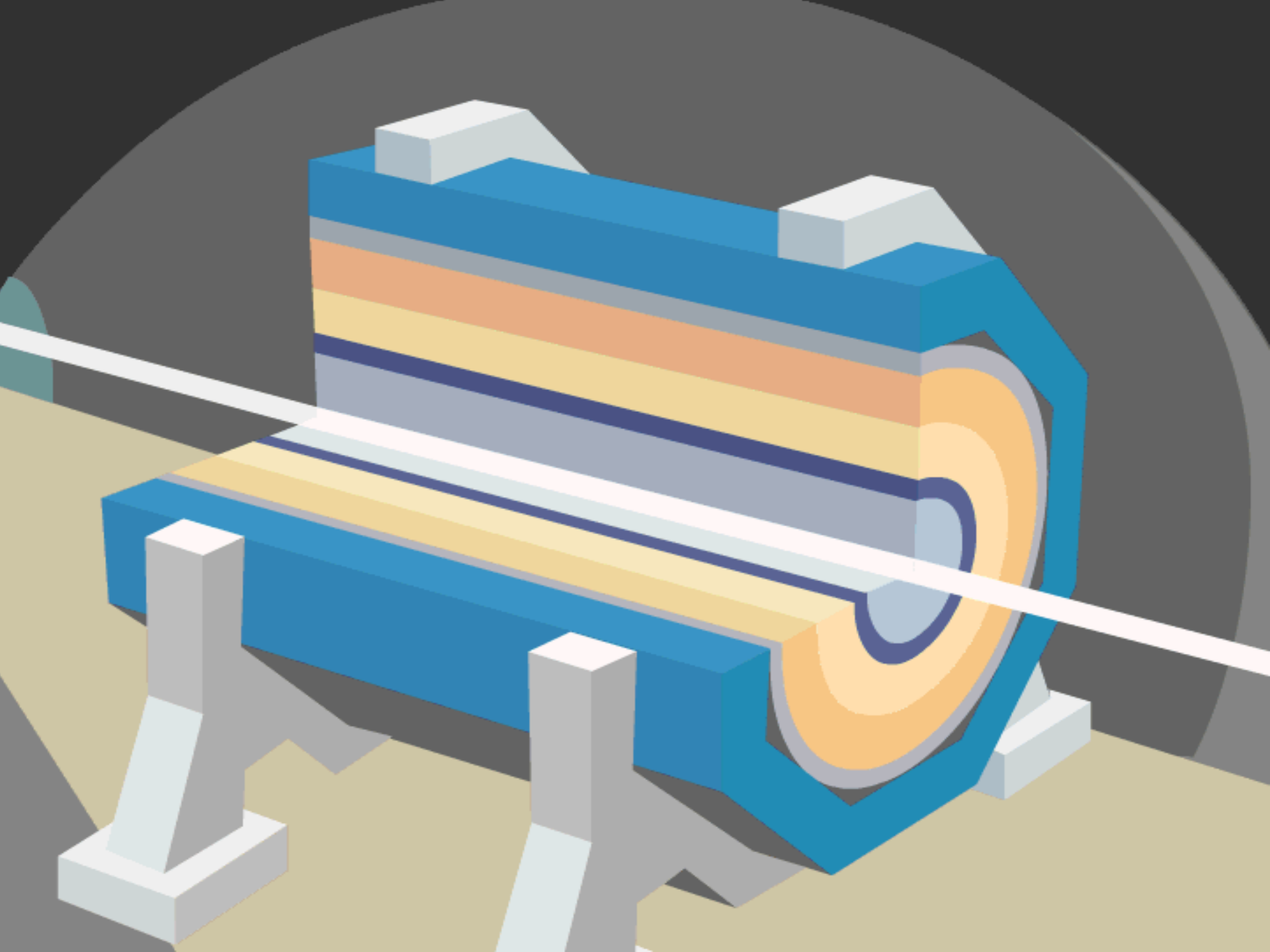


p (proton)
ion
neutron

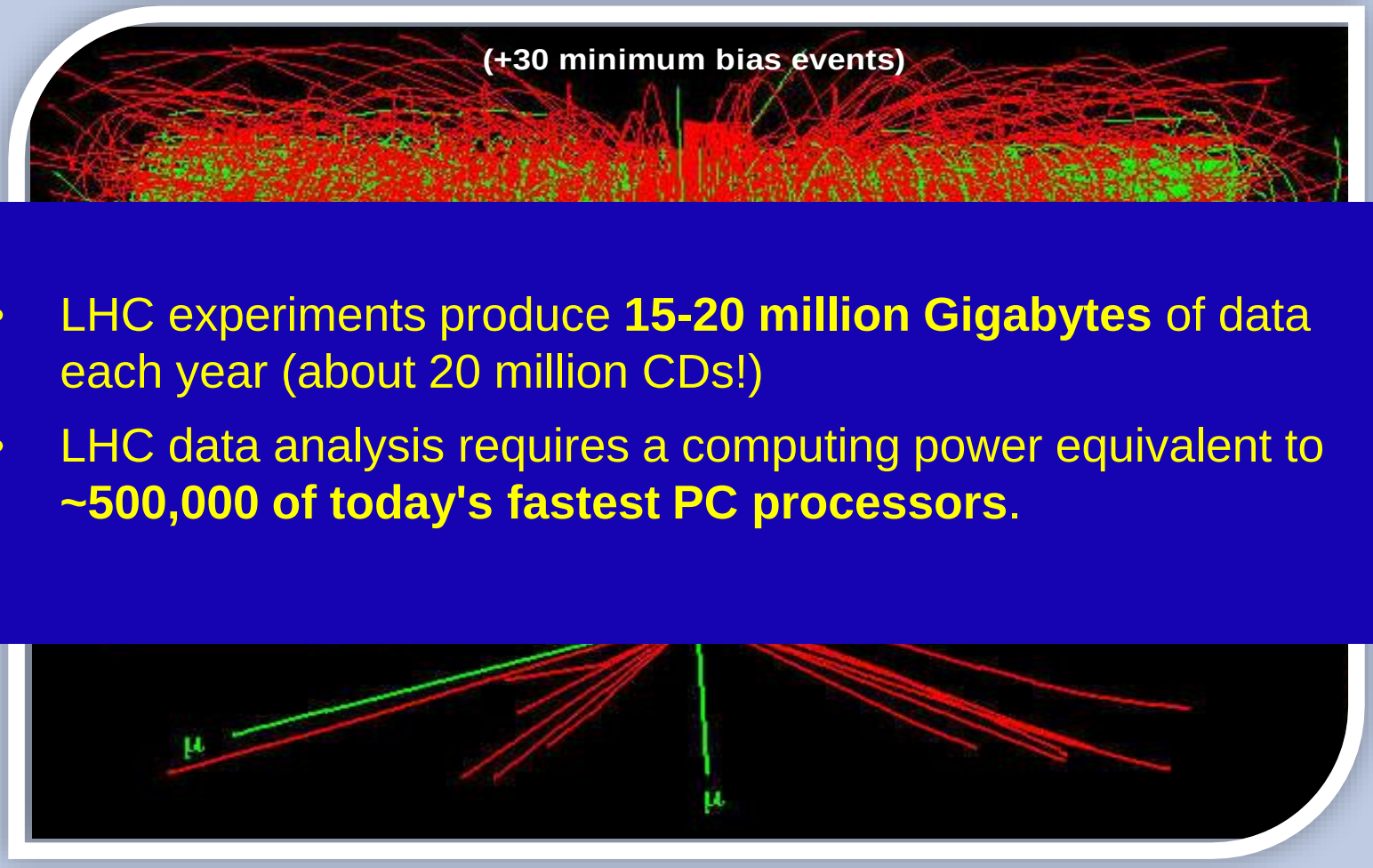
$\bar{p}$ (antiproton)
proton/antiproton conversion
neutrino

AD Antiproton Decelerator
PS Proton Synchrotron
SPS Super Proton Synchrotron

LHC Large Hadron Collider
n-ToF Neutron Time of Flight
CNGS Cern Neutrinos Gran Sasso

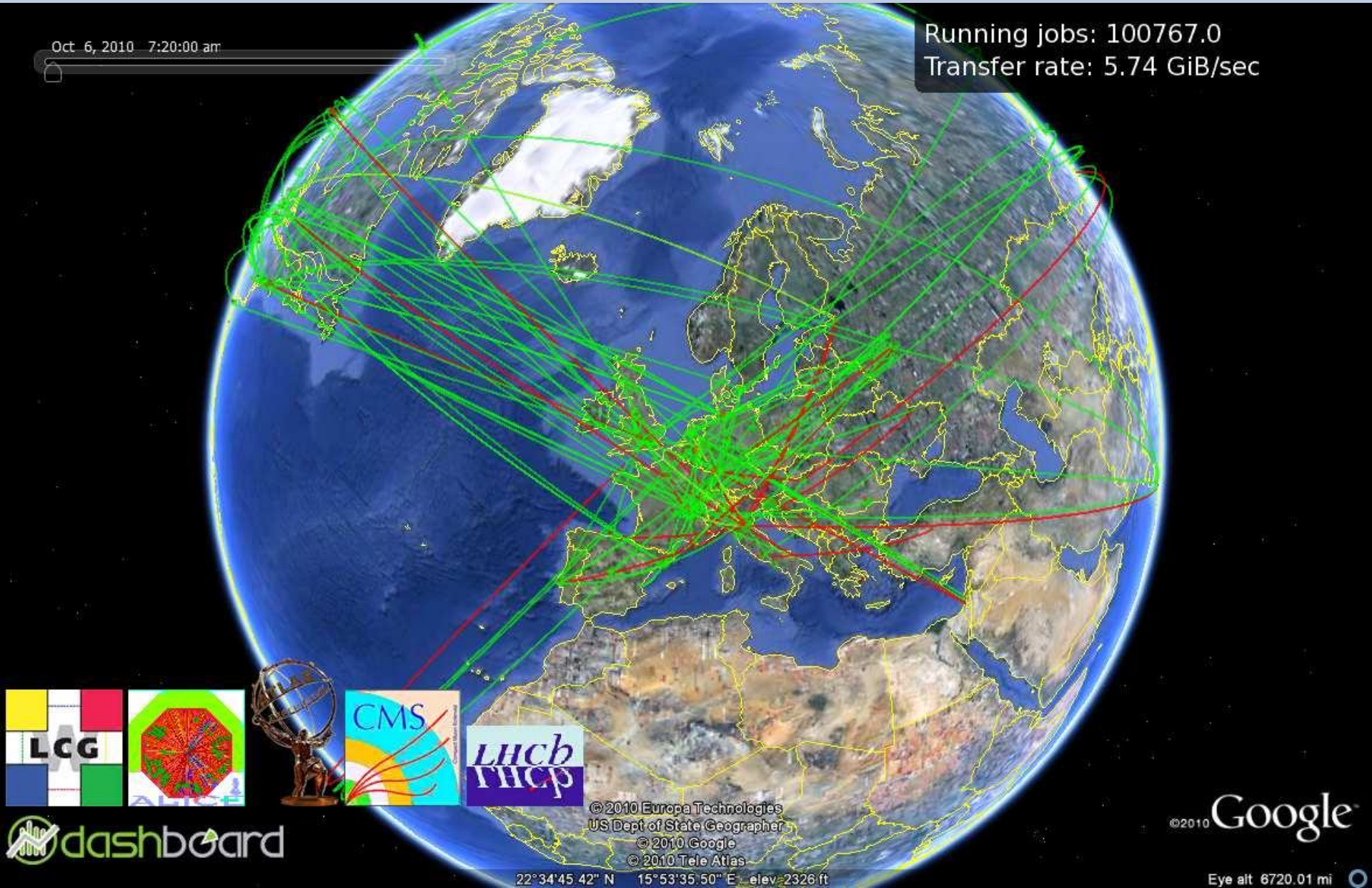


- Searching for new particles requires selection and analysis of enormous quantity of data from LHC detectors



- LHC experiments produce **15-20 million Gigabytes** of data each year (about 20 million CDs!)
- LHC data analysis requires a computing power equivalent to **~500,000 of today's fastest PC processors**.

LCG-LHC Computing GRID

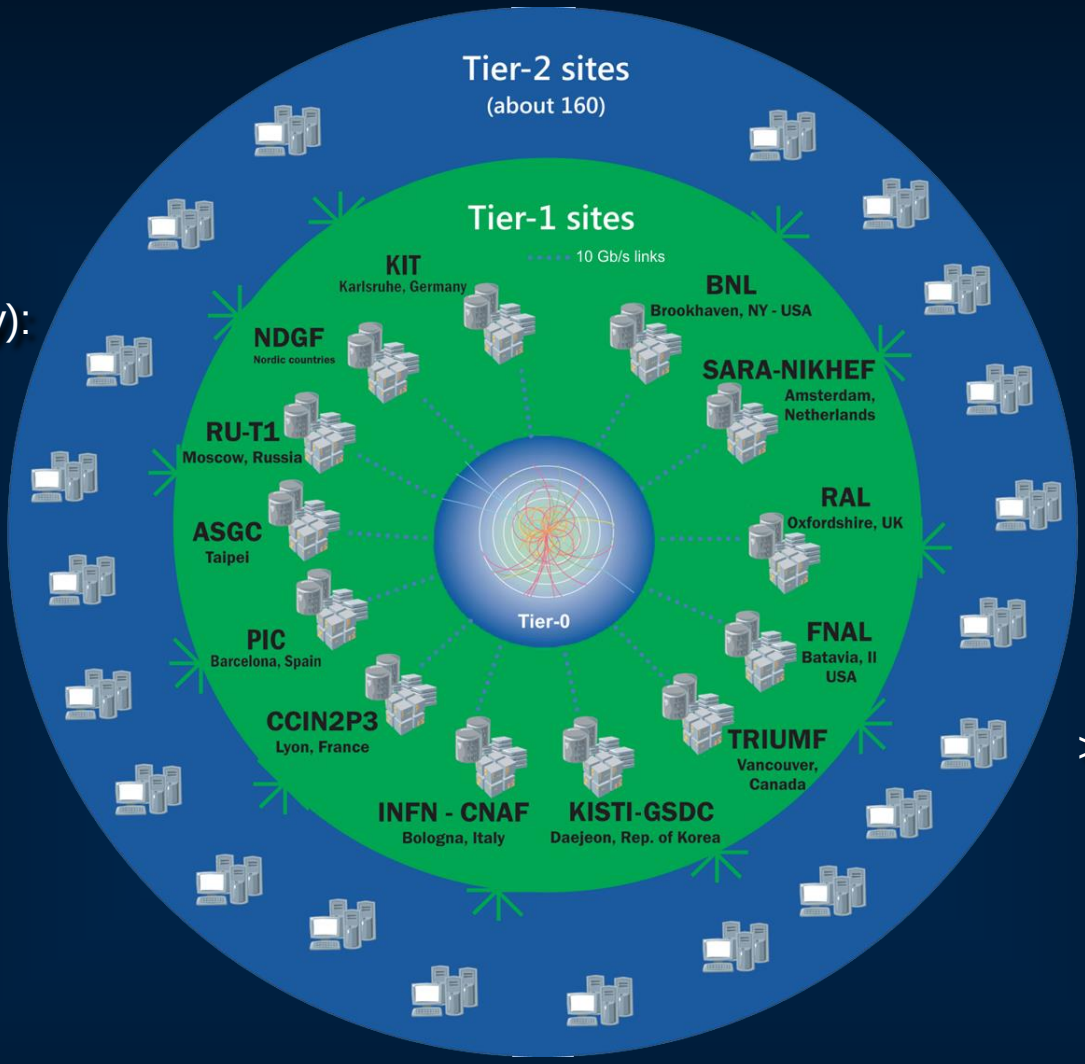


The Worldwide LHC Computing Grid

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

Tier-1: permanent
storage, re-
processing,
analysis

Tier-2: Simulation,
end-user analysis



~170 sites,
40 countries

~500k CPU cores

500 PB of storage

> 2 million jobs/day

10-100 Gb links

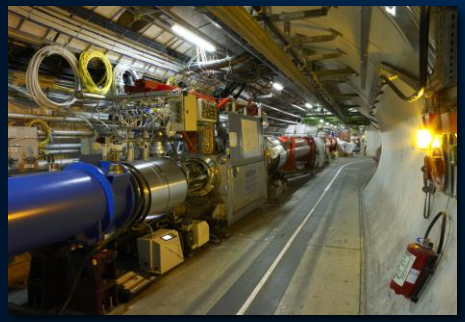
WLCG:
An International collaboration to distribute and analyse LHC data

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

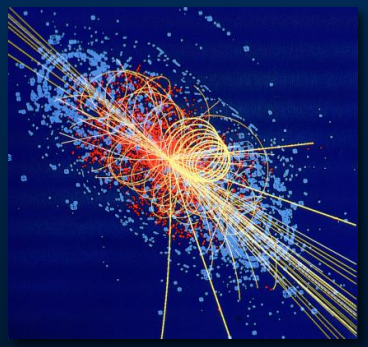
CERN: Particle Physics and Innovation

- Interfacing between fundamental science and key technological developments

- CERN Technologies and Innovation



Accelerating particle beams

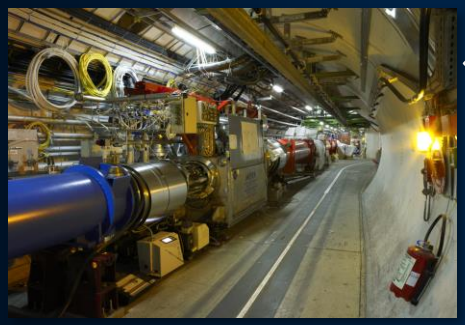


Detecting particles

Large-scale computing (Grid)

Medical Application as an Example of Particle Physics Spin-off

Combining Physics, ICT, Biology and Medicine to fight cancer

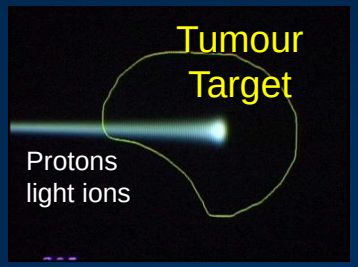


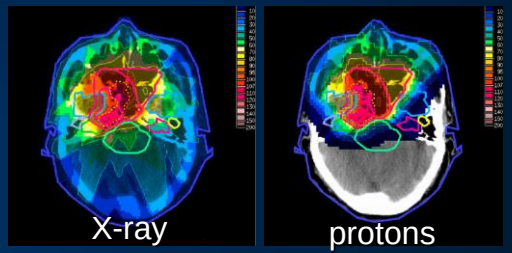
Accelerating particle beams

~30’000 accelerators worldwide

~17’000 used for medicine

Hadron Therapy

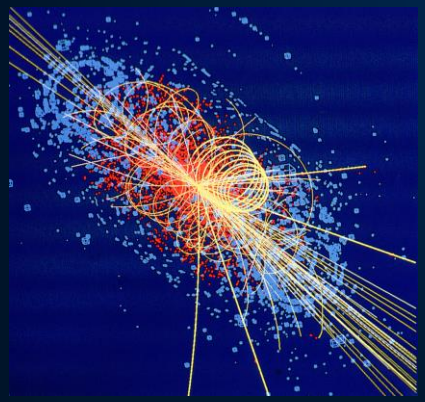




Leadership in Ion Beam Therapy now in Europe and Japan

>70’000 patients treated worldwide (30 facilities)

>21’000 patients treated in Europe (9 facilities)

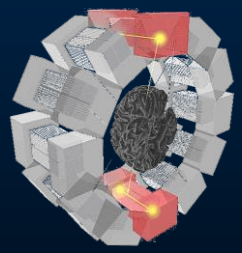


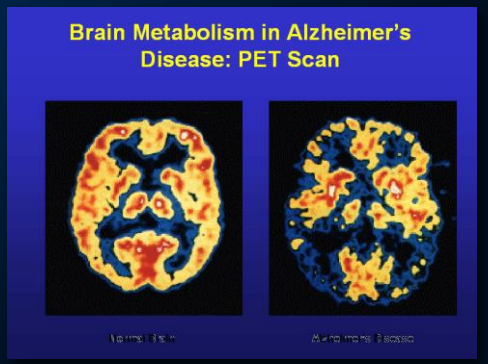
Detecting particles

Imaging

Clinical trial in Portugal for new breast imaging system (ClearPEM)

PET Scanner





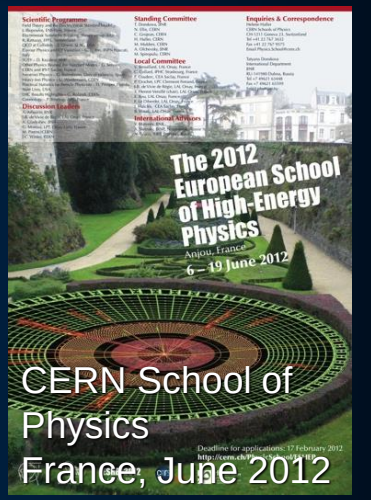
CERN Education Activities

Scientists at CERN
Academic Training Programme


NEW:
Asia-Europe-Pacific School of High-Energy Physics
Fukuoka, Oct 2012


Latin American School
Natal, Brazil, 2011

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



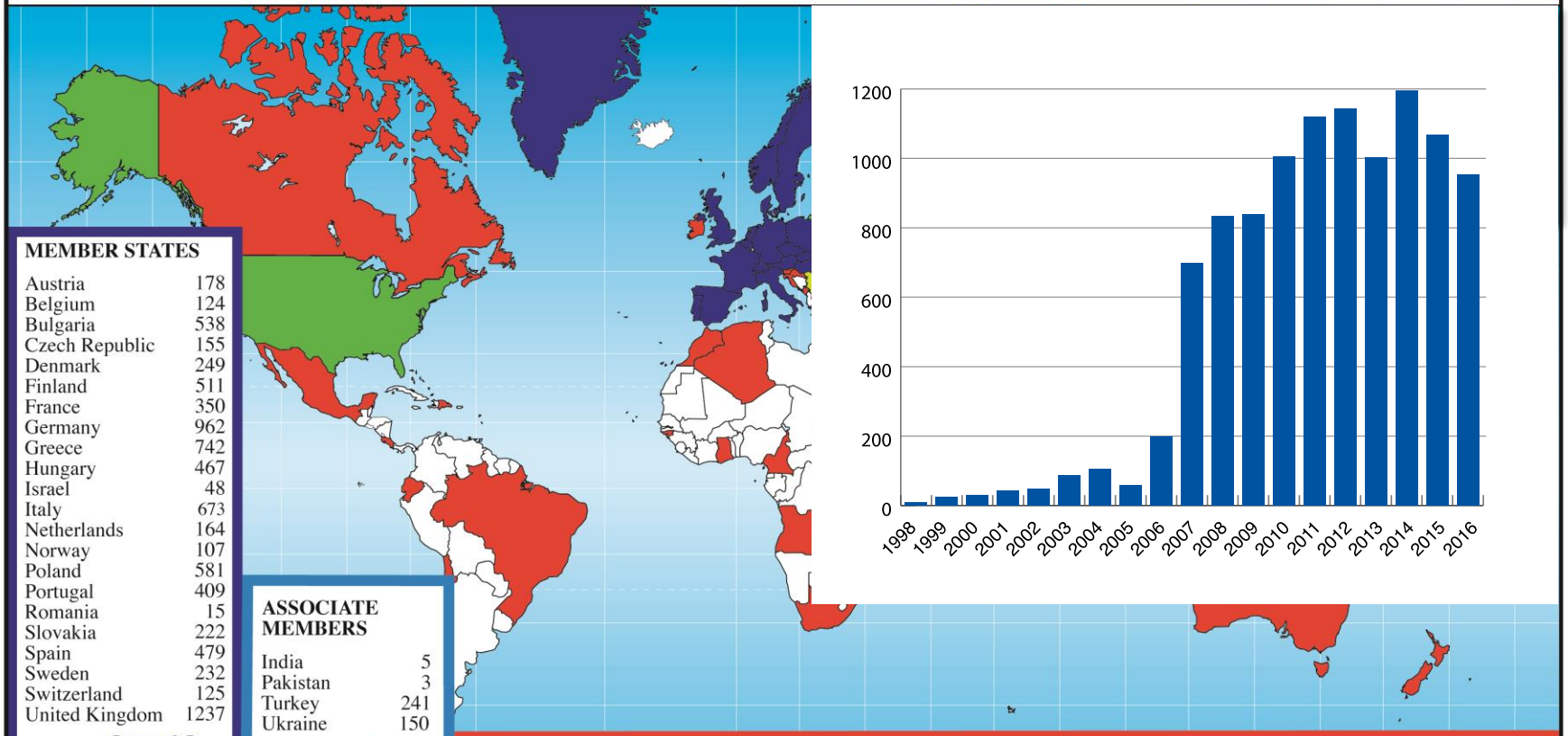
CERN School of Physics
France, June 2012

Physics Students
Summer Students Programme

CERN Teacher Schools
International and National Programmes

CERN Teacher Programme

Teacher Programme Participants 1998 - 2016 (Total: 10462)



MEMBER STATES

Austria	178
Belgium	124
Bulgaria	538
Czech Republic	155
Denmark	249
Finland	511
France	350
Germany	962
Greece	742
Hungary	467
Israel	48
Italy	673
Netherlands	164
Norway	107
Poland	581
Portugal	409
Romania	15
Slovakia	222
Spain	479
Sweden	232
Switzerland	125
United Kingdom	1237

8568

ASSOCIATE MEMBERS

India	5
Pakistan	3
Turkey	241
Ukraine	150

399

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP

Cyprus	10
Serbia	68

78

OBSERVERS

Japan	8
Russia	379
USA	102

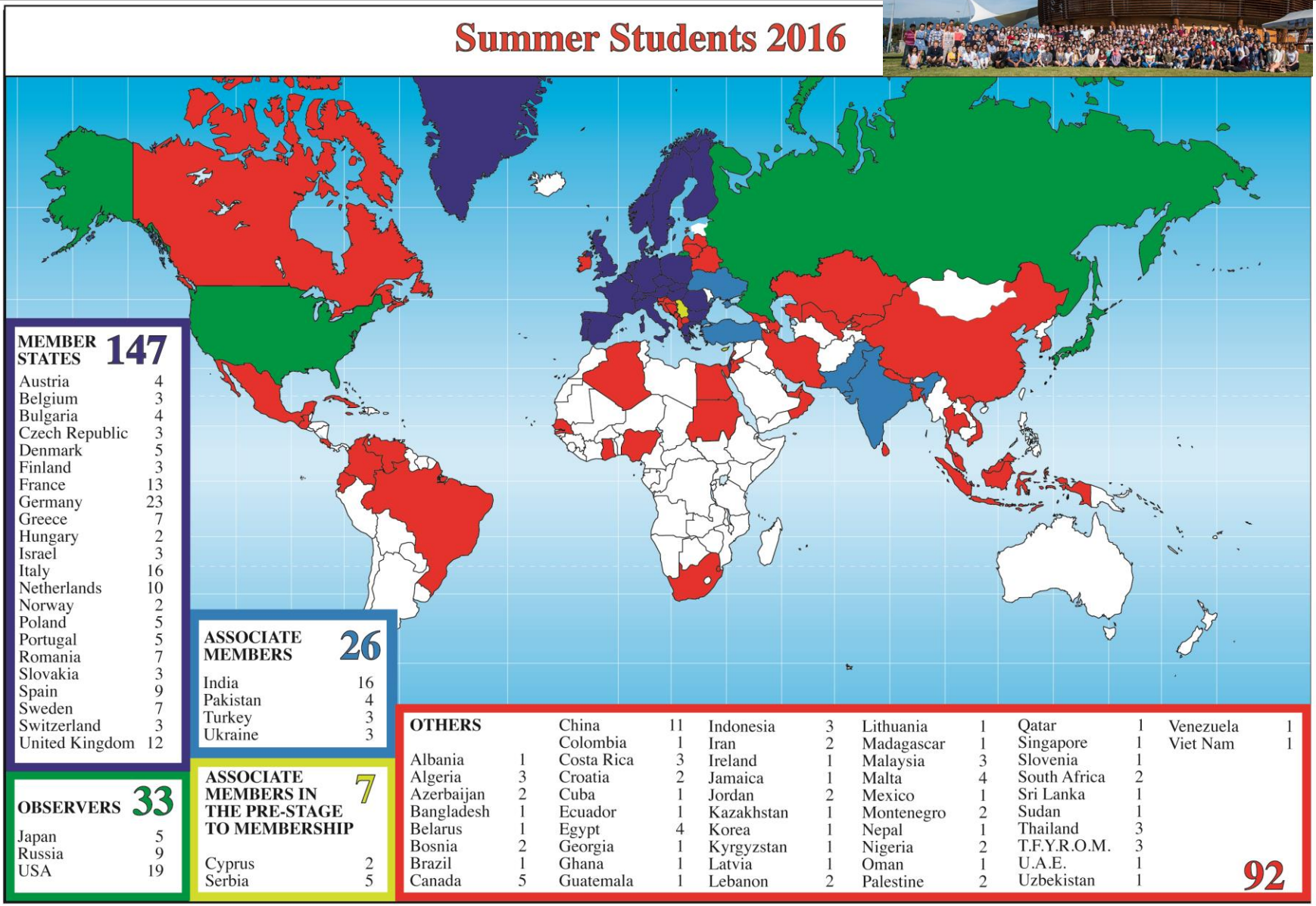
489

OTHERS

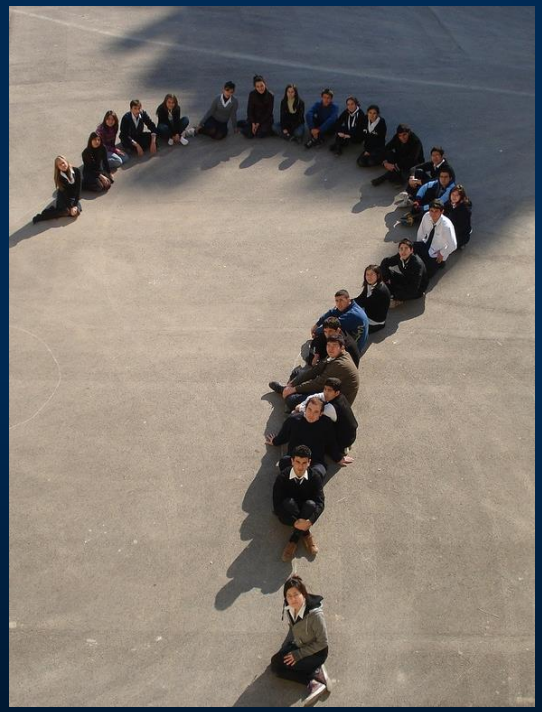
Algeria	8	Canada	9	Ghana	6	Malta	36	Sao Tome	7	Uganda	3
Angola	7	Cape Verde	4	Guinea Bissau	1	Mexico	27	Saudi Arabia	1	U.A.E.	1
Armenia	1	Chile	3	Iran	7	Mongolia	1	Singapore	2		
Australia	7	China	2	Ireland	8	Montenegro	15	Slovenia	21		
Azerbaijan	1	Costa Rica	4	Jordan	12	Morocco	2	South Africa	8		
Bahrain	2	Croatia	23	Kazakhstan	8	Mozambique	22	South Korea	48		
Belarus	3	Dominican Rep.	71	Kenya	4	Nepal	2	Swaziland	1		
Brazil	187	Ecuador	2	Latvia	25	New Zealand	2	Taiwan	1		
Burundi	2	Egypt	2	Lebanon	1	Palestine (O.T.)	4	Thailand	14		
Cameroon	5	Estonia	79	Lithuania	51	Qatar	1	T.F.Y.R.O.M.	12		
		Georgia	121	Madagascar	2	Rwanda	20	Timor-Leste	9		

928

Summer Students 2016



Personnel



Workforce

- Physicists
  - Experimental
  - Theoretical
- Applied Physicists and Engineers
- Technicians
- Craftsmen
- Administrative personnel
- Fellows
- Doctoral Students
- Technical Students
- Associates
- Summer Students
- Employees of CERN
- Users

30th November 2009 LHC sets new world record

Early this morning CERN's Large Hadron Collider become the world's highest energy particle accelerator, having accelerated its twin beams of protons to an energy of **1.18 TeV** . This exceeds the previous world record of 0.98 TeV, which had been held by the US Fermi National Accelerator

What next ?

ATLAS and CMS experiments present Higgs search status

13 December 2011. In a seminar held at CERN[1] today, the ATLAS[2] and CMS[3] experiments presented the status of their searches for the Standard Model Higgs boson.

Their results are based on the analysis of considerably more data than those presented at the summer conferences, sufficient to make significant progress in the search for the Higgs boson, but not enough to make any conclusive statement on the existence or non-existence of the elusive Higgs.

The main conclusion is that the Standard Model Higgs boson, if it exists, is most likely to have a mass constrained to the range 116-130 GeV by the ATLAS experiment, and 115-127 GeV by CMS.

Tantalising hints have been seen by both experiments in this mass region, but these are not yet strong enough to claim a discovery.

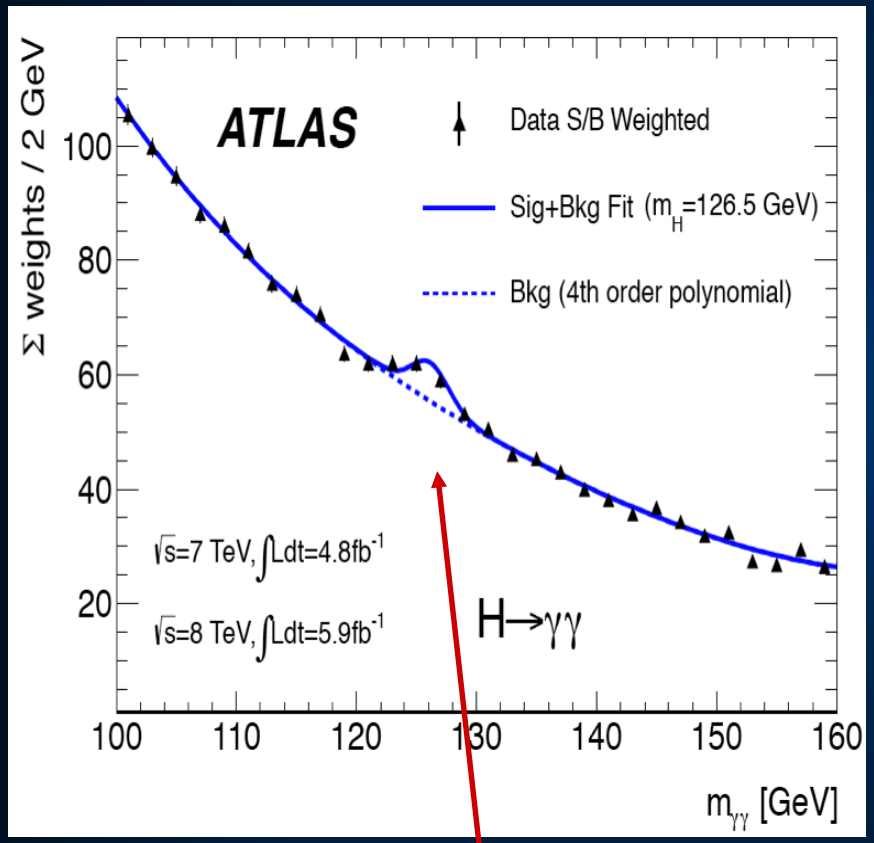
CERN experiments observe particle consistent with long-sought Higgs boson
Geneva, 4 July 2012.

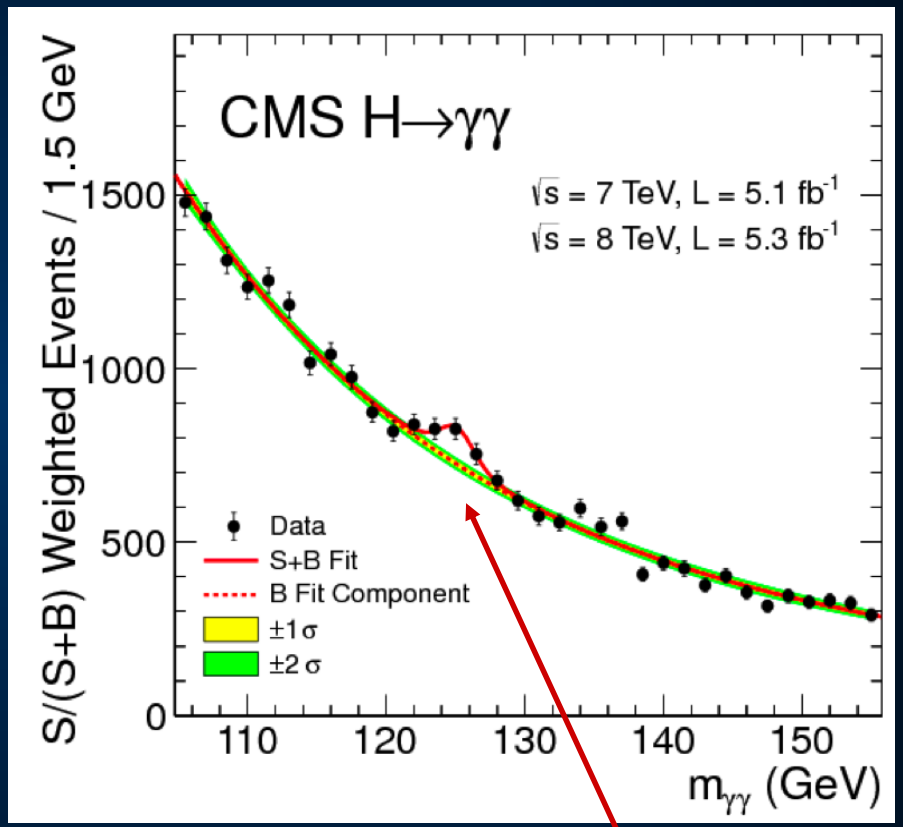
At a seminar held at CERN[1] today as a curtain raiser to the year's major particle physics conference, ICHEP2012 in Melbourne, the ATLAS and CMS experiments presented their latest preliminary results in the search for the long sought Higgs particle. **Both experiments observe a new particle in the mass region around 125-126 GeV**.

*"**We observe in our data clear signs of a new particle, at the level of 5 sigma, in the mass region around 126 GeV**. The outstanding performance of the LHC and ATLAS and the huge efforts of many people have brought us to this exciting stage,"* said ATLAS experiment spokesperson Fabiola Gianotti, *"but a little more time is needed to prepare these results for publication."*

*"**The results are preliminary but the 5 sigma signal at around 125 GeV we're seeing is dramatic**. This is indeed a new particle. We know it must be a boson and it's the heaviest boson ever found,"* said CMS experiment spokesperson Joe Incandela. *"**The implications are very significant and it is precisely for this reason that we must be extremely diligent in all of our studies and cross-checks**."*

Higgs decay to $\gamma\gamma$, ATLAS and CMS, summer 2012 data





July 4th at CERN, after the Higgs seminar

4 JULY 2012
CERN Press conference

Peter Higgs and Francois Englert