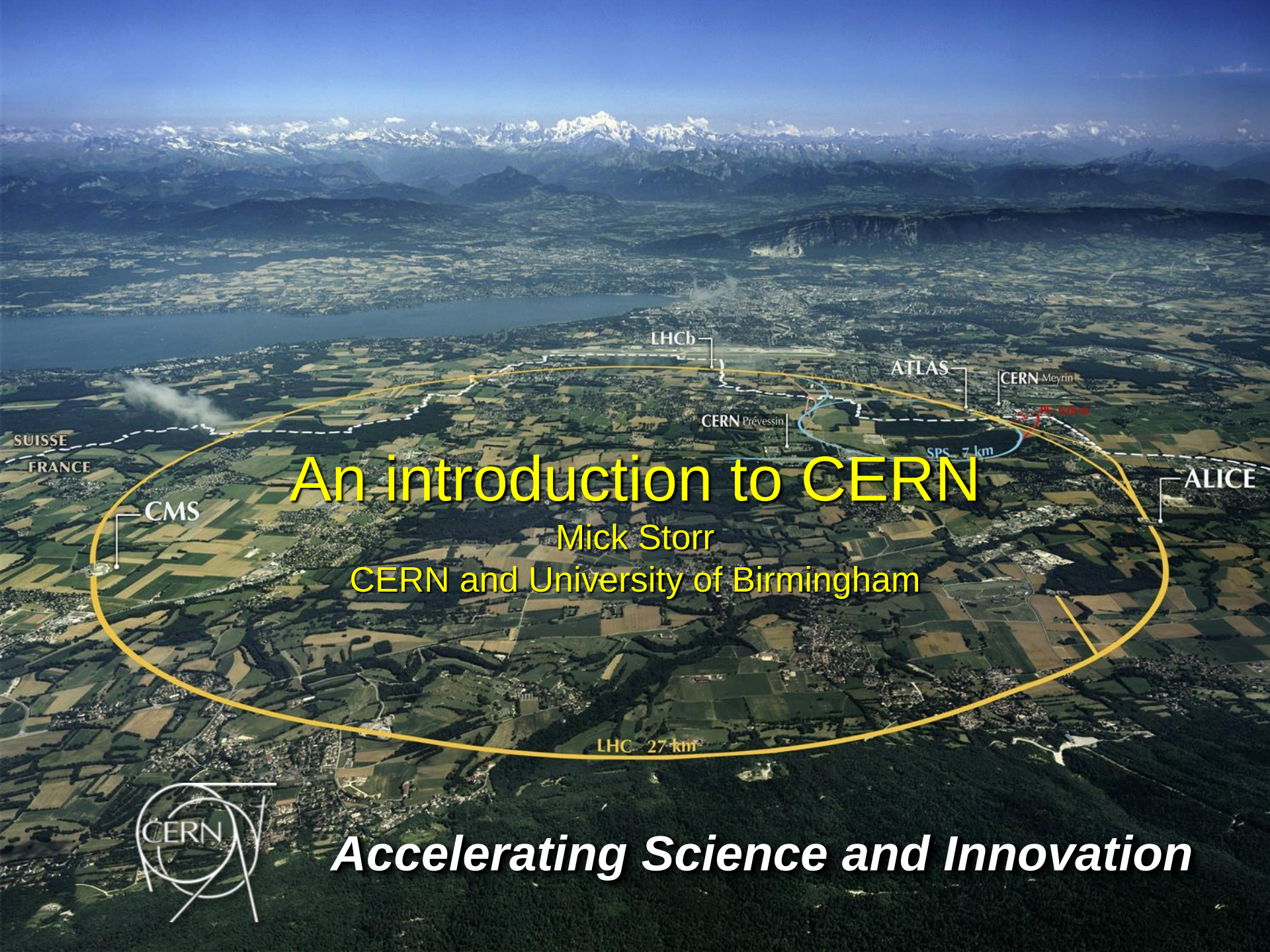


An introduction to CERN

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 was founded 1954: 12 European States

"Science for Peace"

Today: 22 Member States

~ 2300 staff
~ 1300 other paid personnel
> 11500 scientific users

Budget (2015) ~1000 MCHF

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

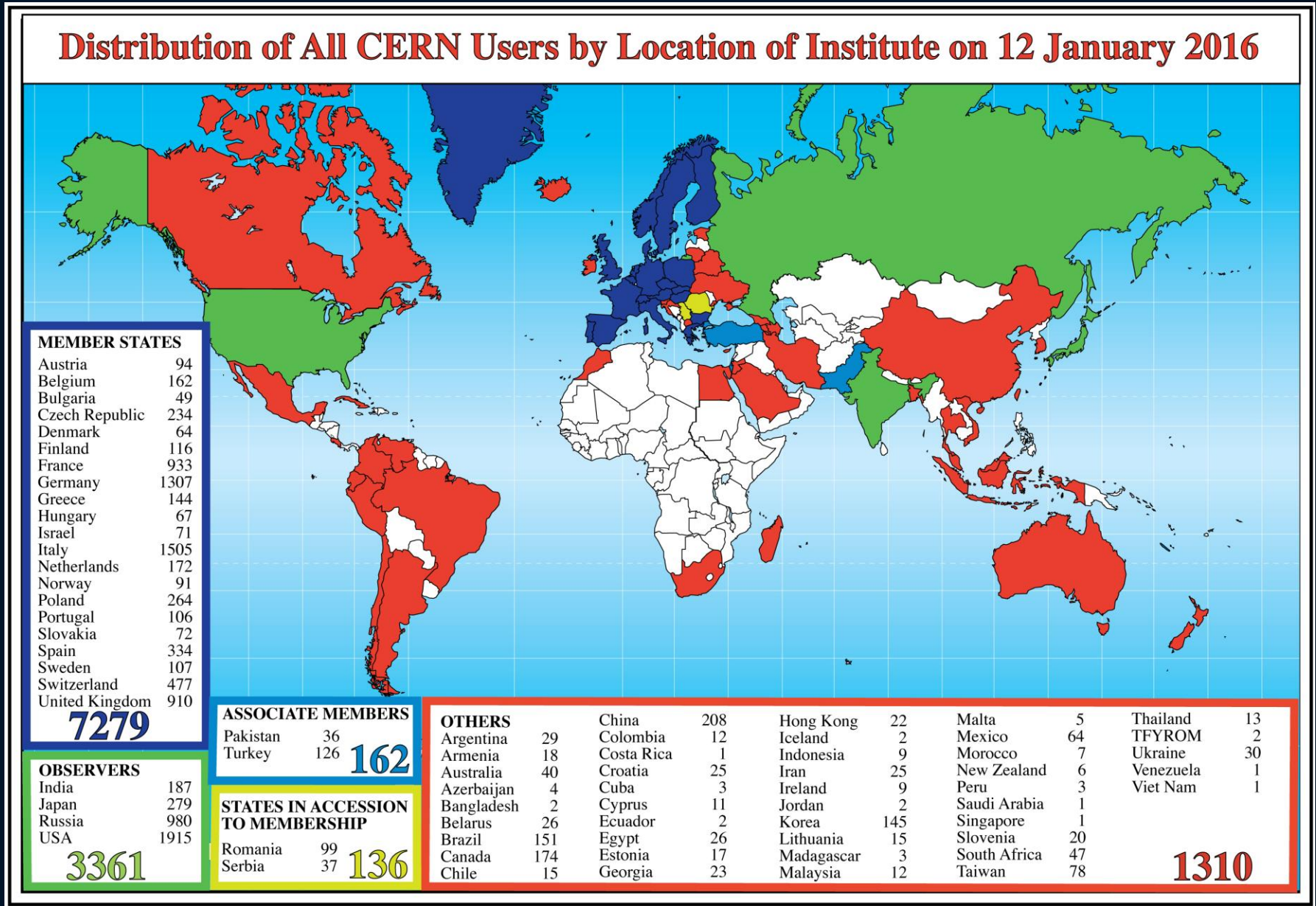
Associate Member States: Cyprus, India, Pakistan, Turkey, Ukraine

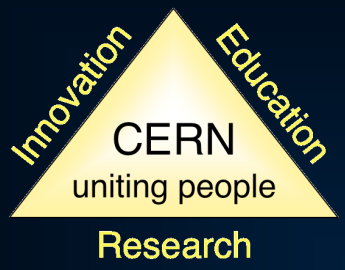
States in accession to Membership: Serbia

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

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

Science is getting more and more global

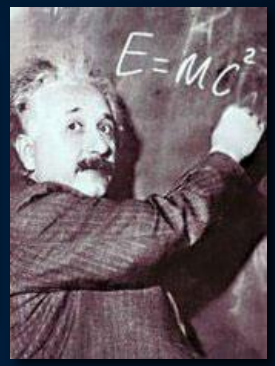




The Mission of CERN

- **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

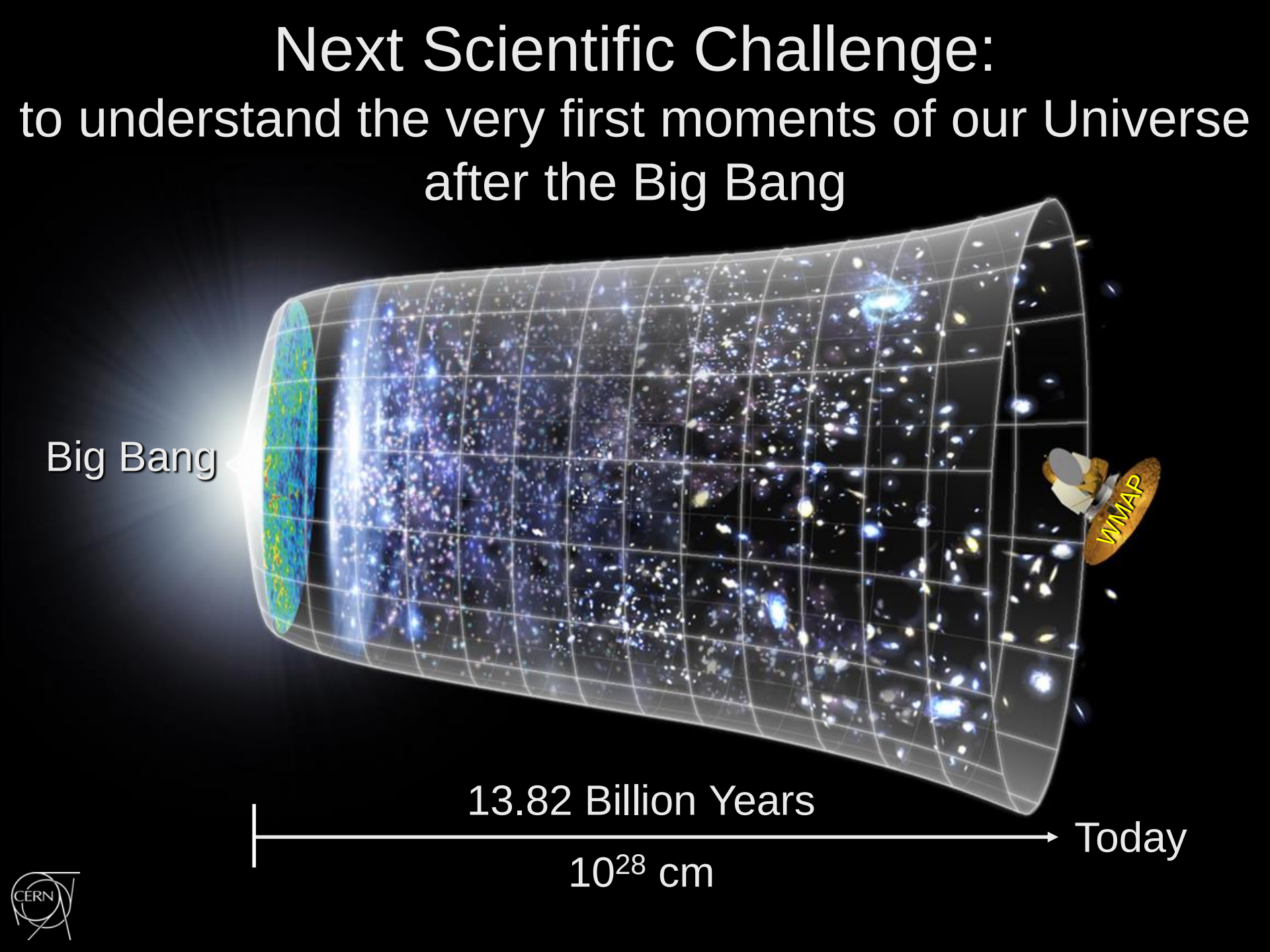
  Information technology - the Web and the GRID

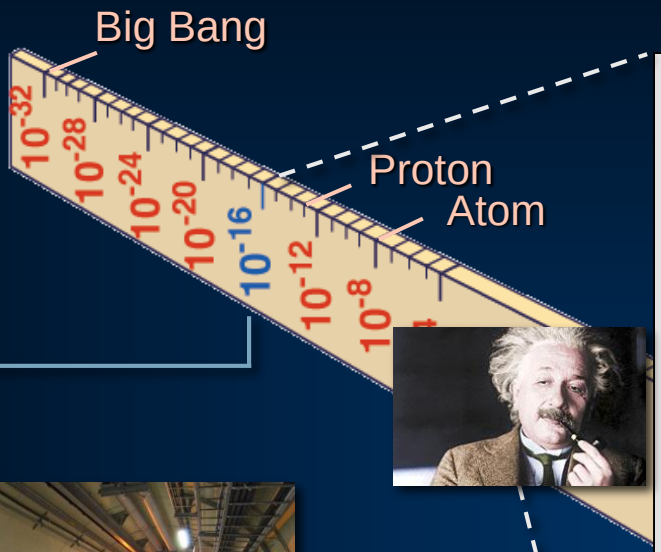
  Medicine - diagnosis and therapy

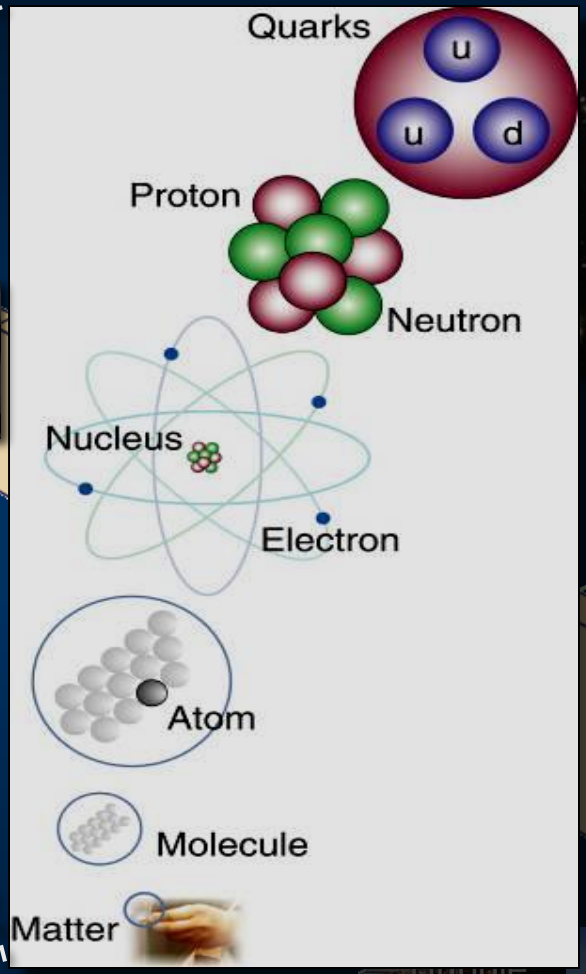
- **Train** scientists and engineers of tomorrow

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

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

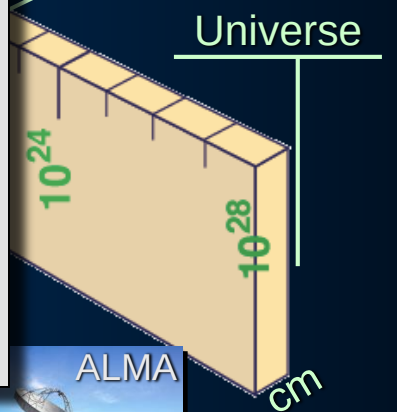


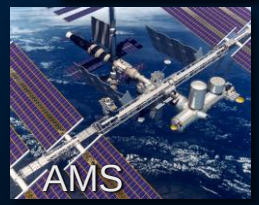




LHC

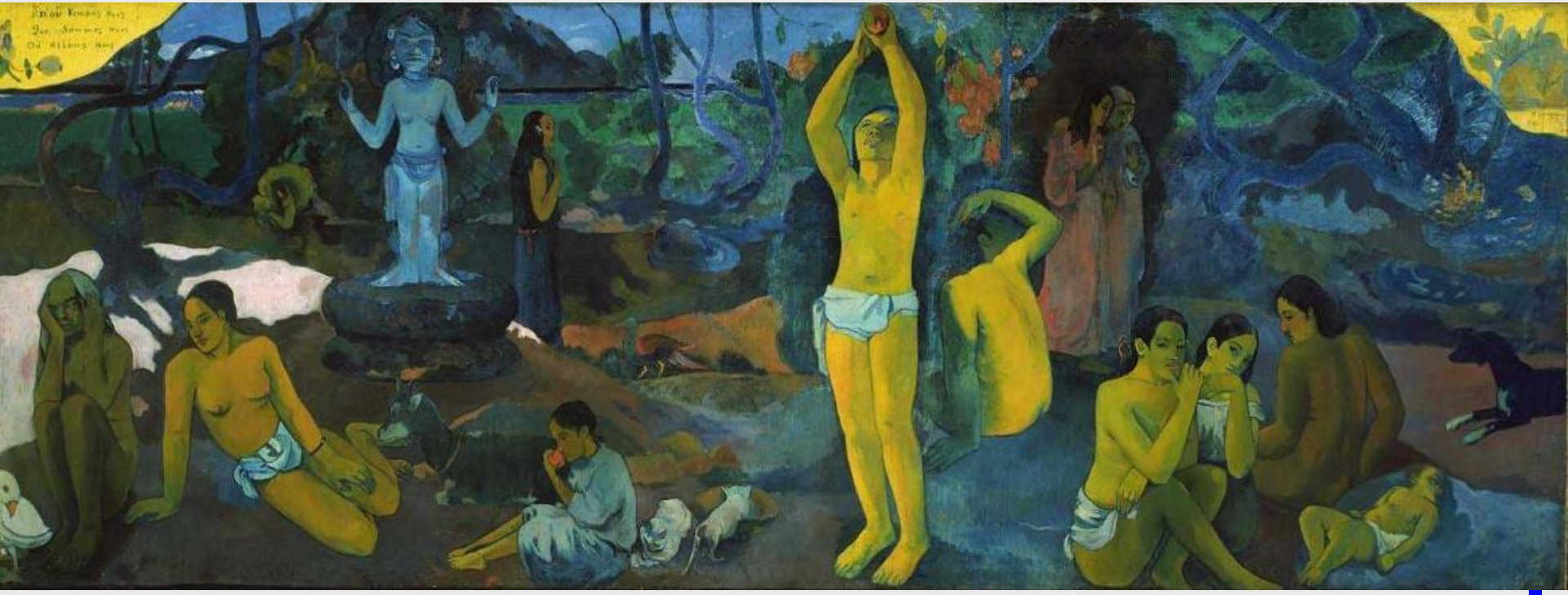
Super-Microscope





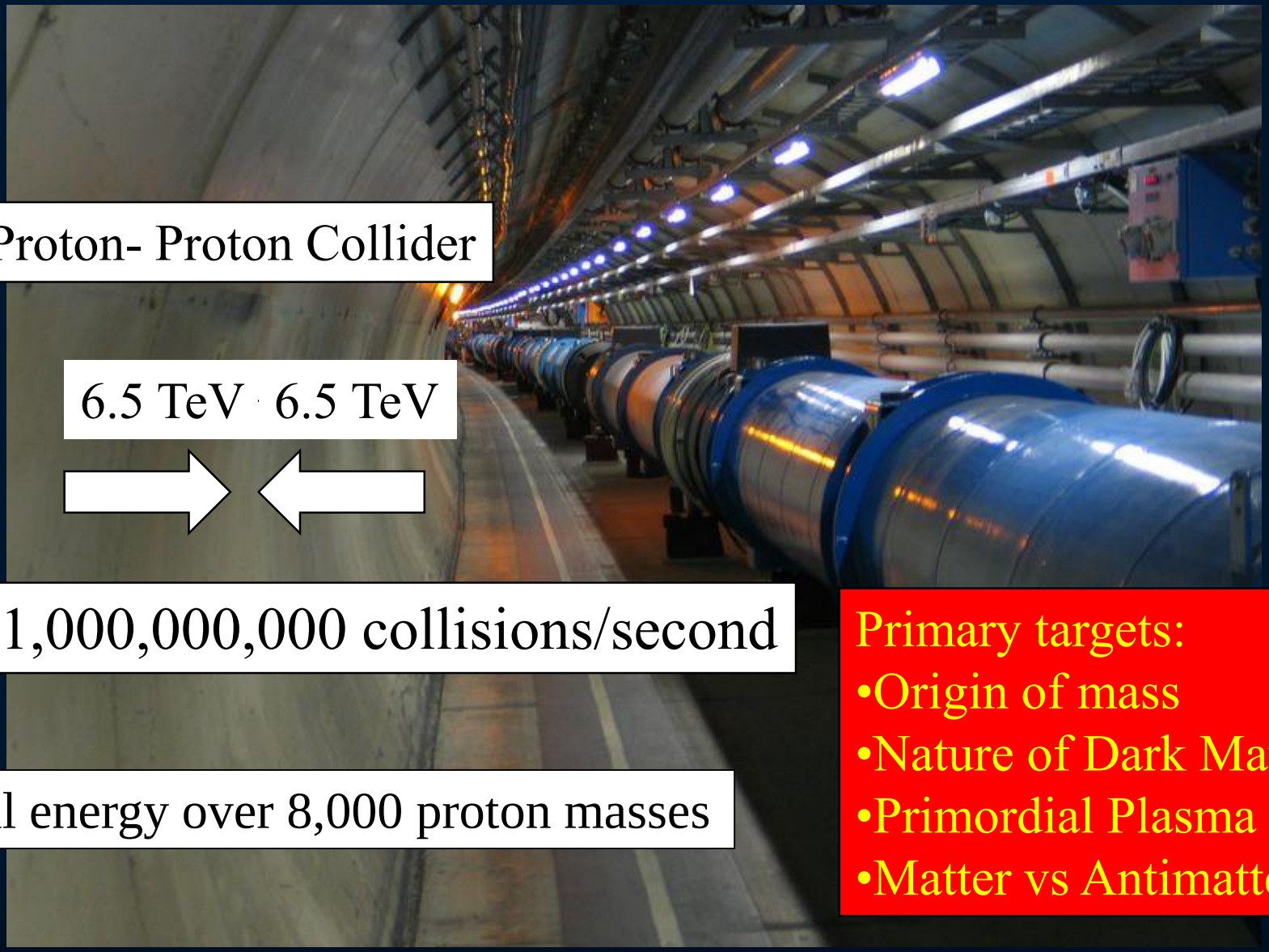
Study physics laws of first moments after Big Bang
increasing Symbiosis between Particle Physics,
Astrophysics and Cosmology

“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

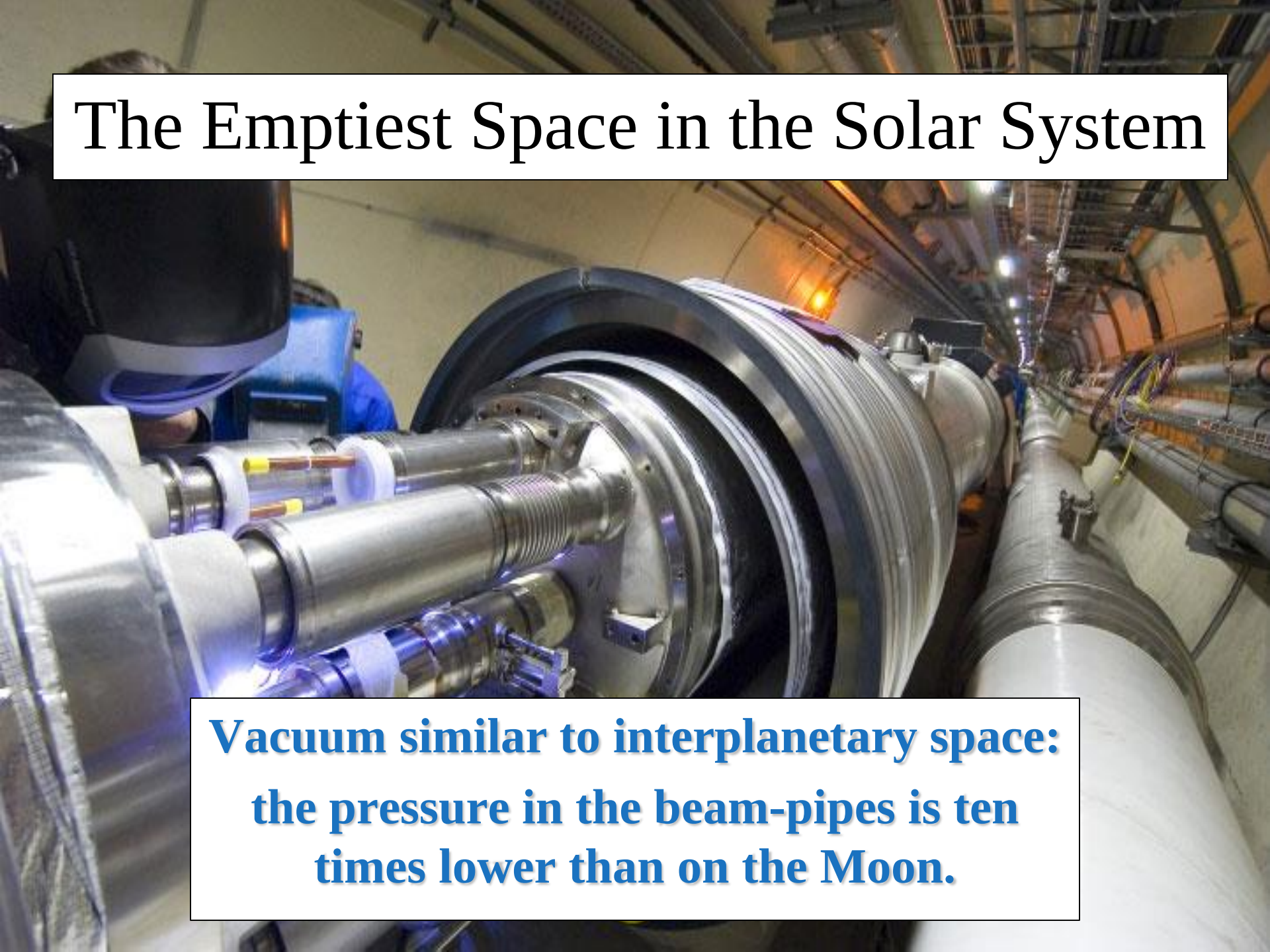
6.5 TeV · 6.5 TeV

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

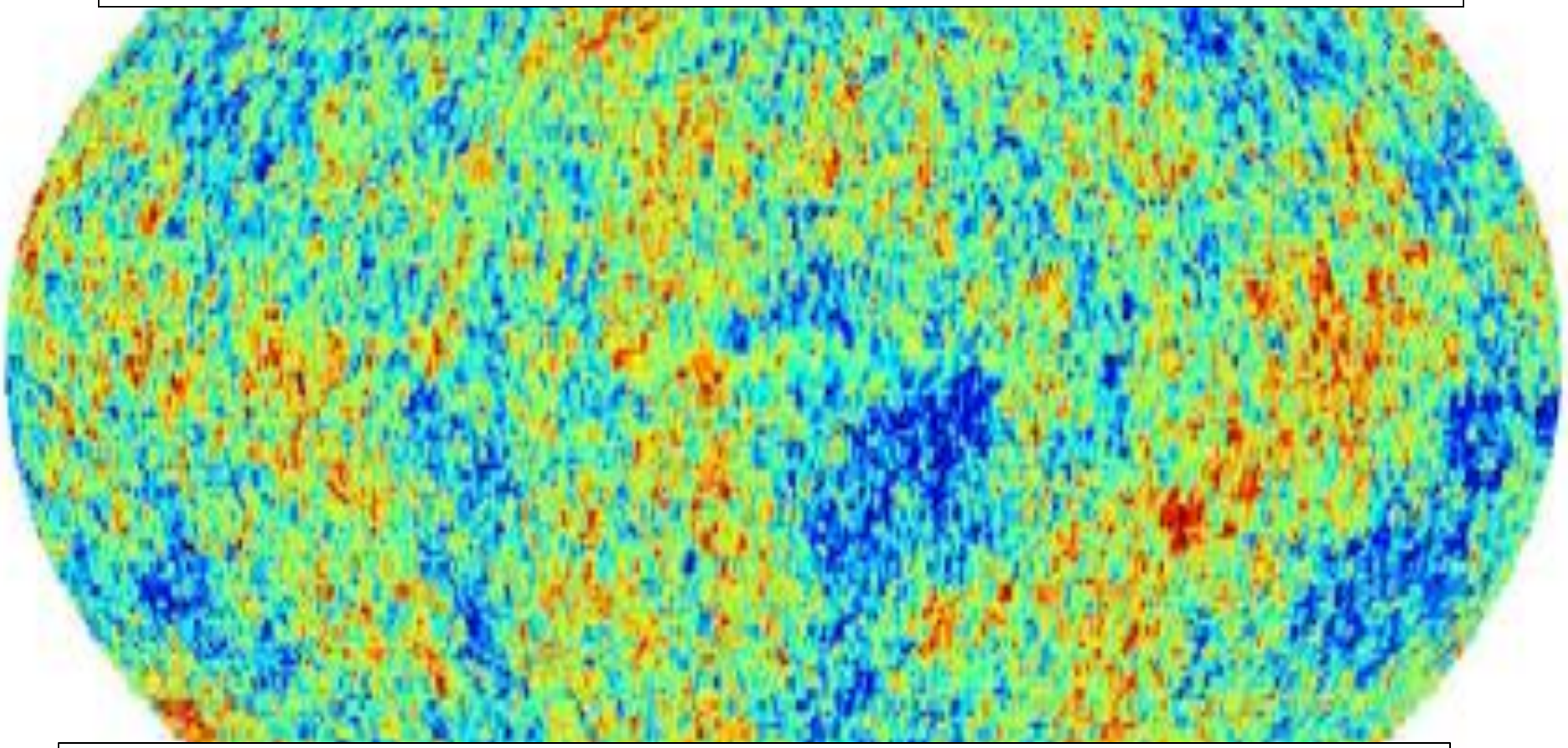
The Emptiest Space in the Solar System



Vacuum similar to interplanetary space:

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

Colder than Outer Space

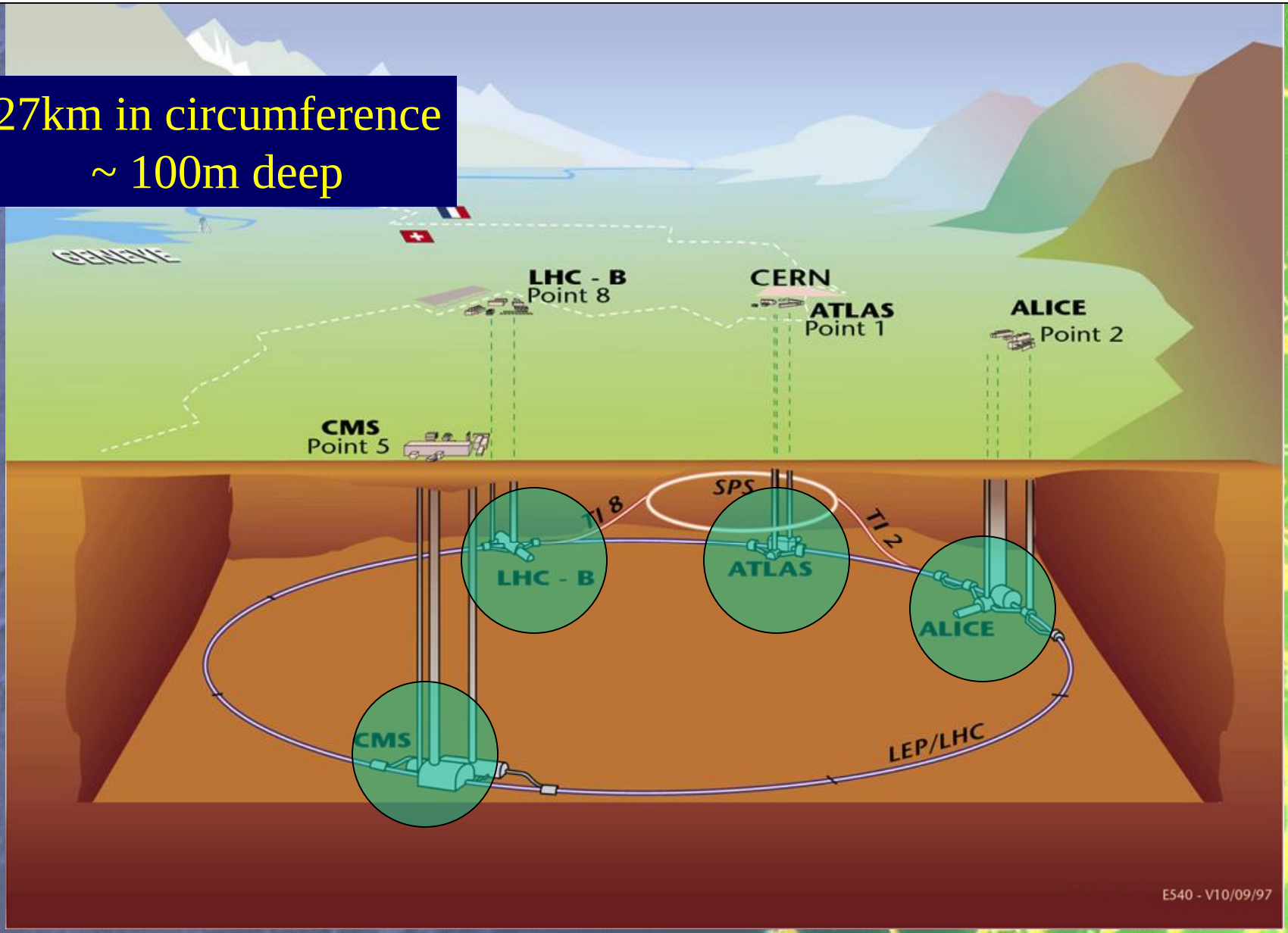


LHC 1.9 degrees above absolute zero = - 271 C

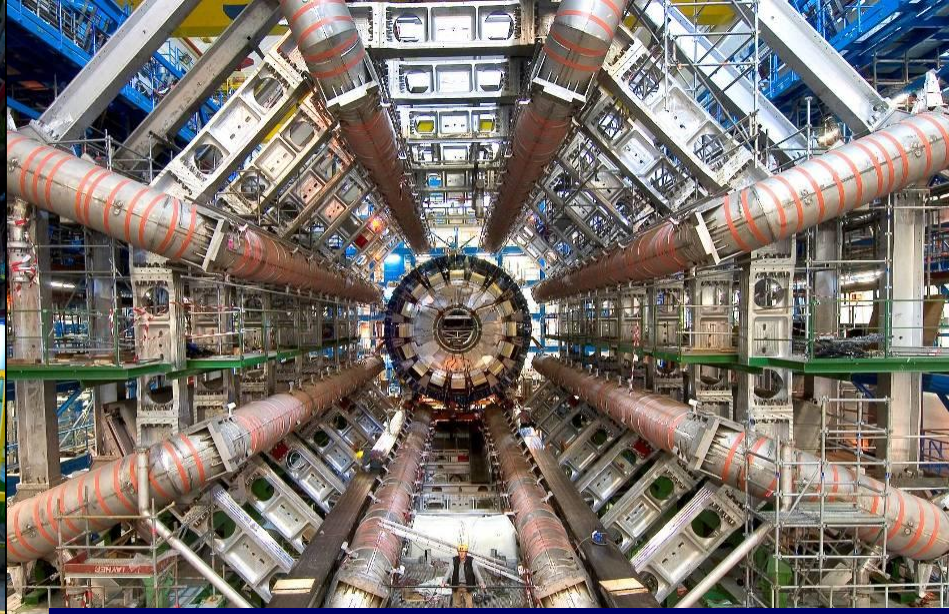
Outer space 2.7 degrees above zero = - 270 C

General View of LHC & its Experiments

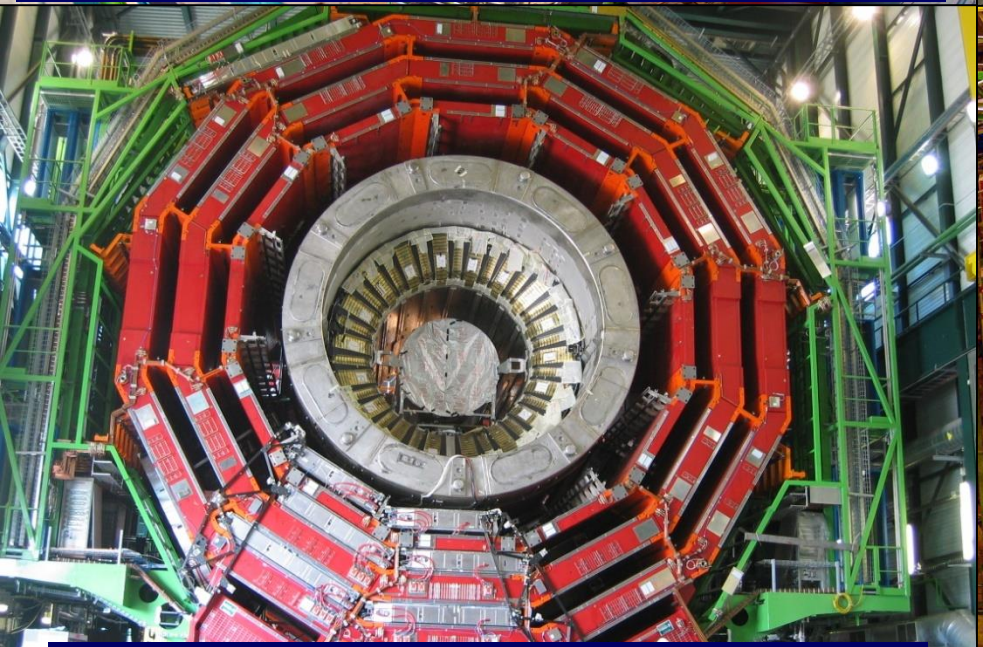
27km in circumference
~ 100m deep



ALICE: Primordial cosmic plasma



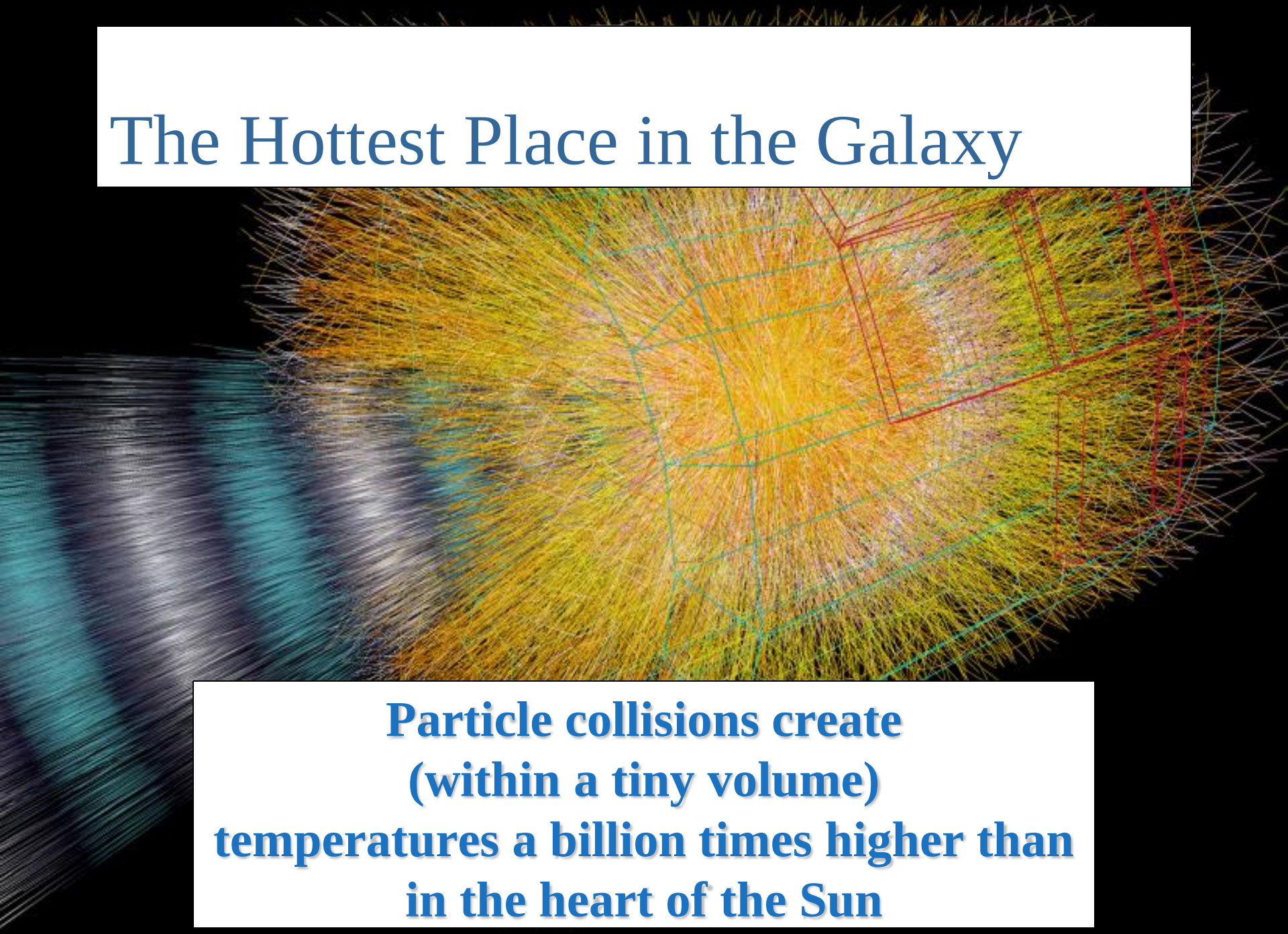
ATLAS: Higgs and supersymmetry



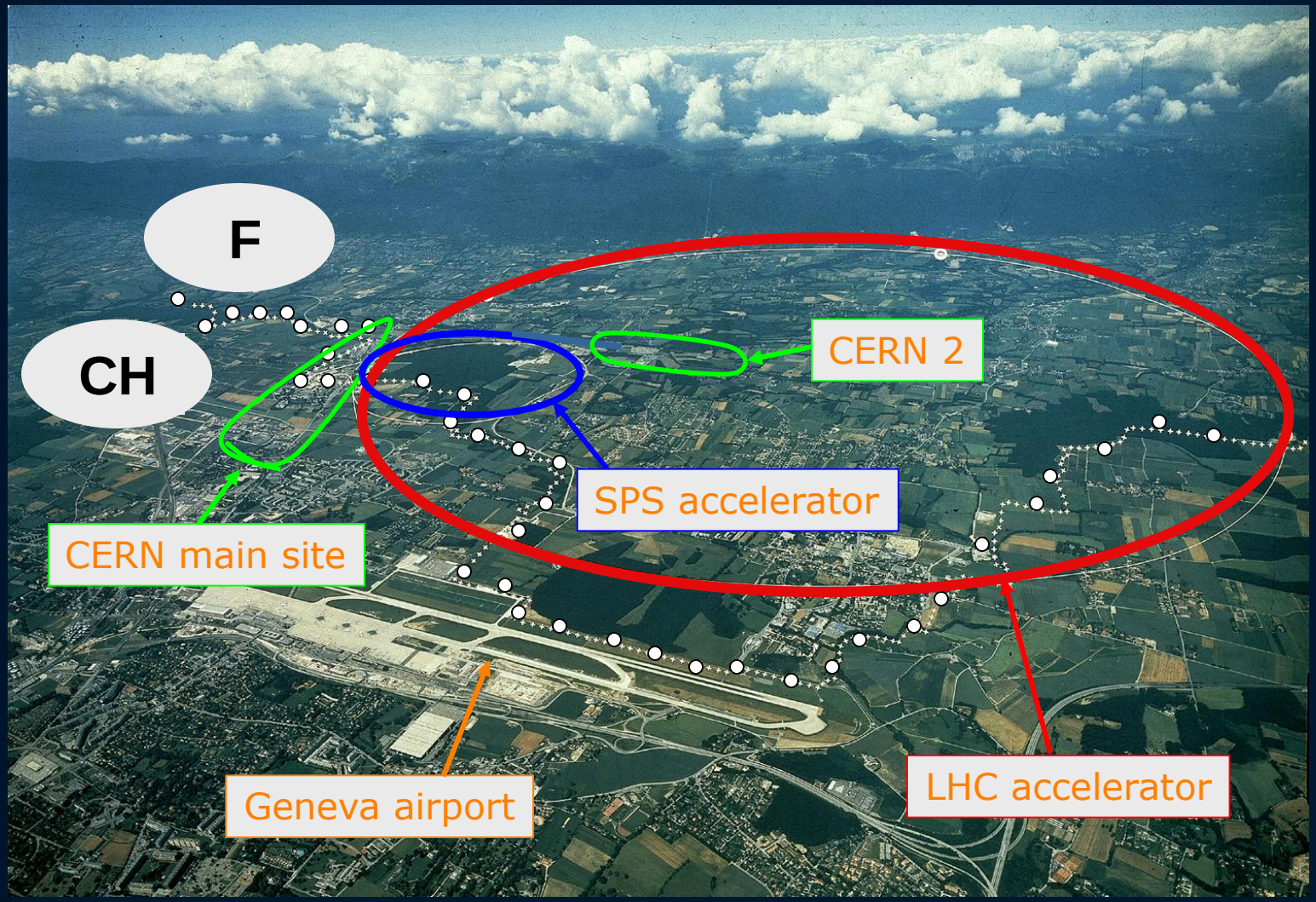
CMS: Higgs and supersymmetry

LHCb: Matter-antimatter differenc

The Hottest Place in the Galaxy

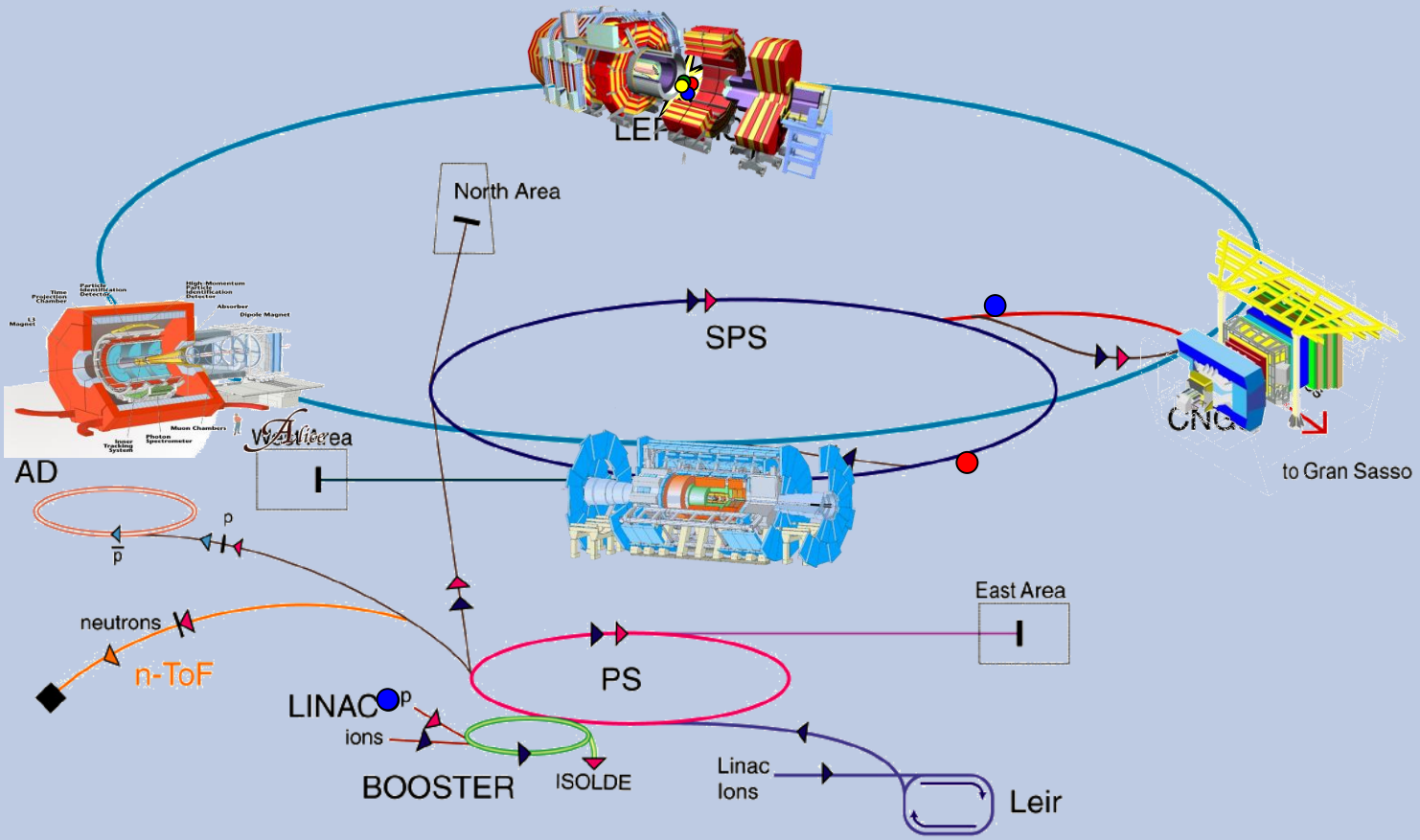


Particle collisions create (within a tiny volume) temperatures a billion times higher than in the heart of the Sun


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

Large Hadron Collider

Collision of proton beams… …observed in giant detectors

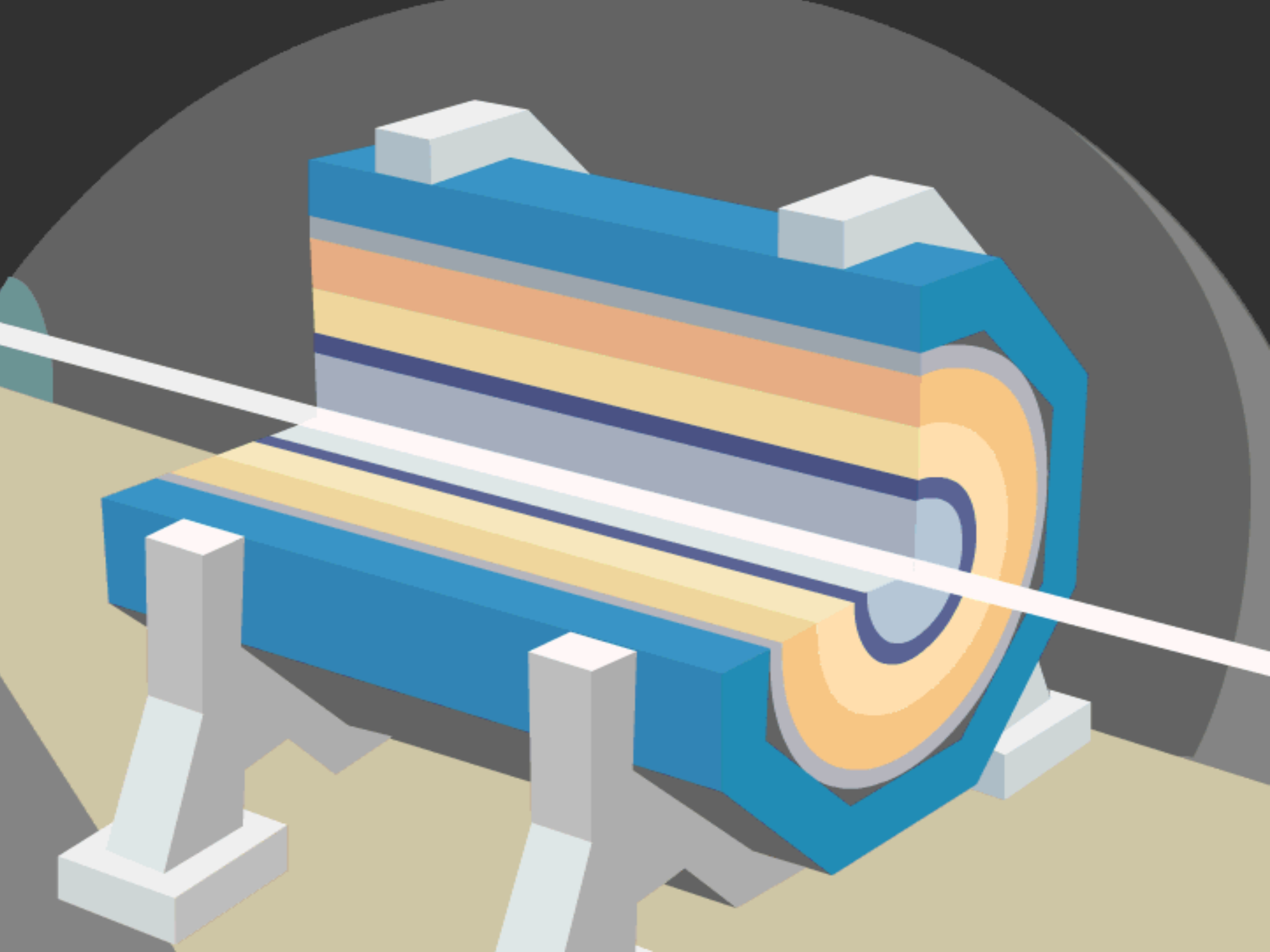


p (proton)
ion
neutron

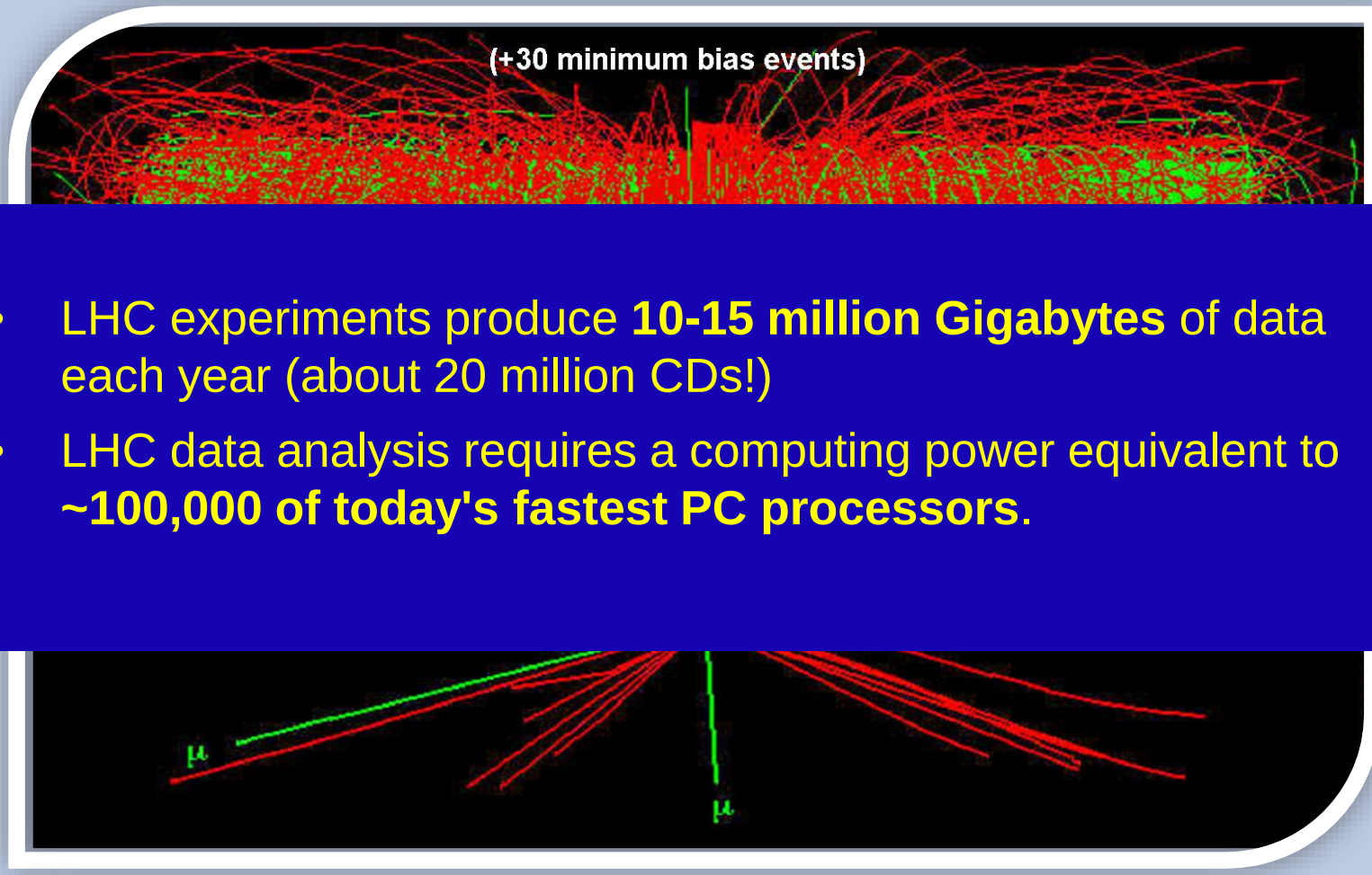
$\bar{p}$ (antiproton)
proton/antiproton conversion
neutrino

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

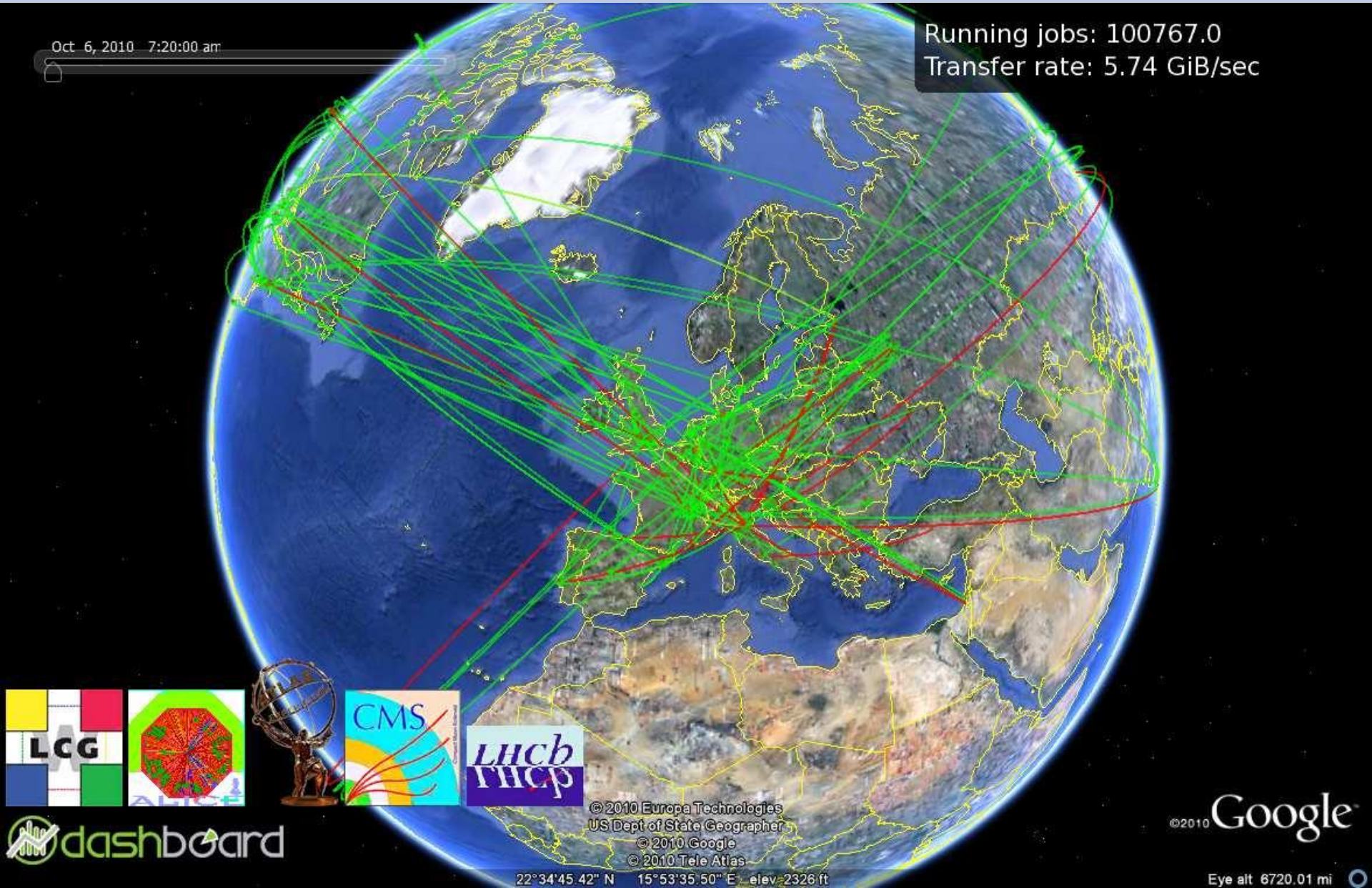


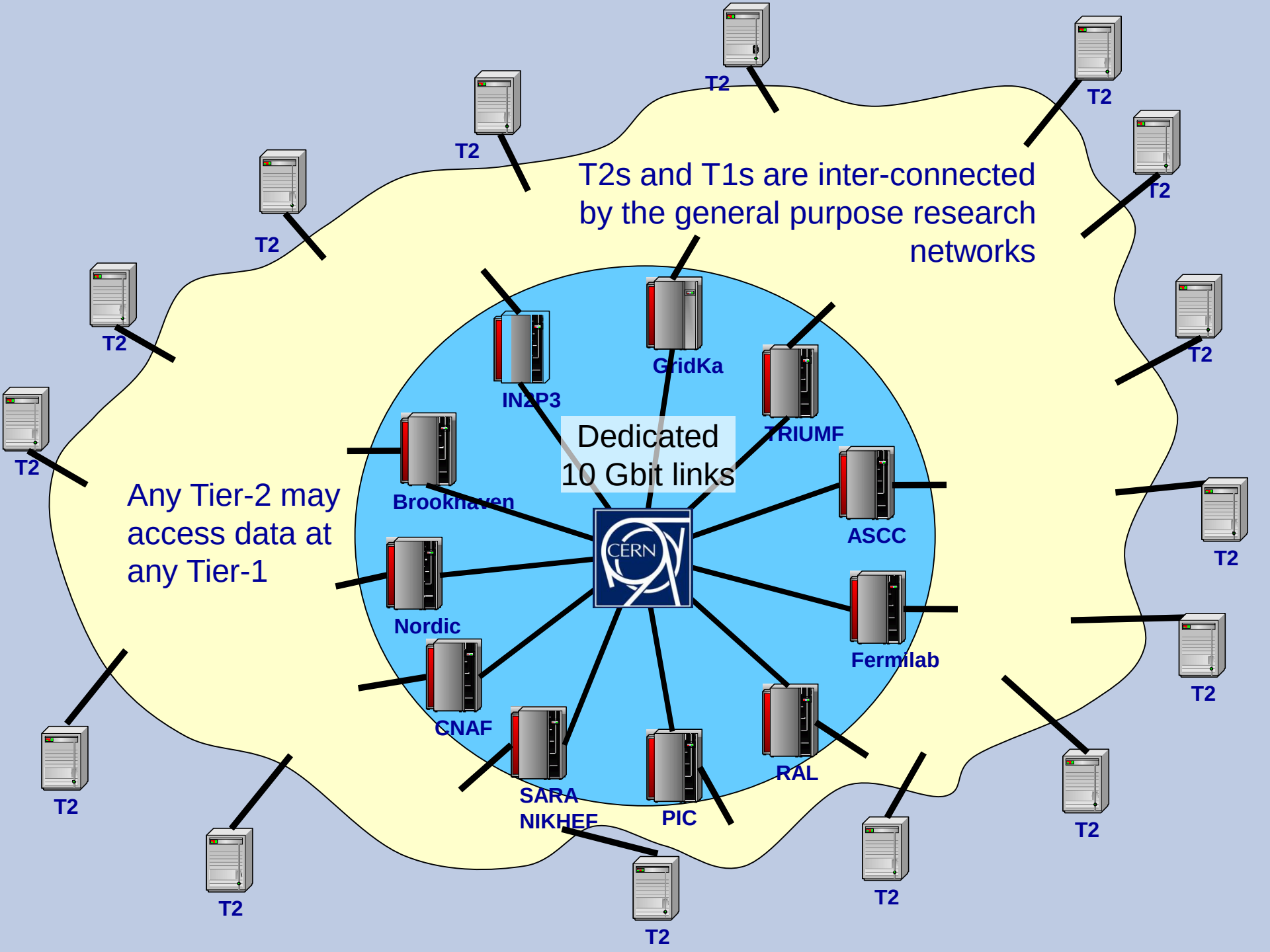
❑ Searching for new particles requires selection and analysis of enormous quantity of data from LHC detectors



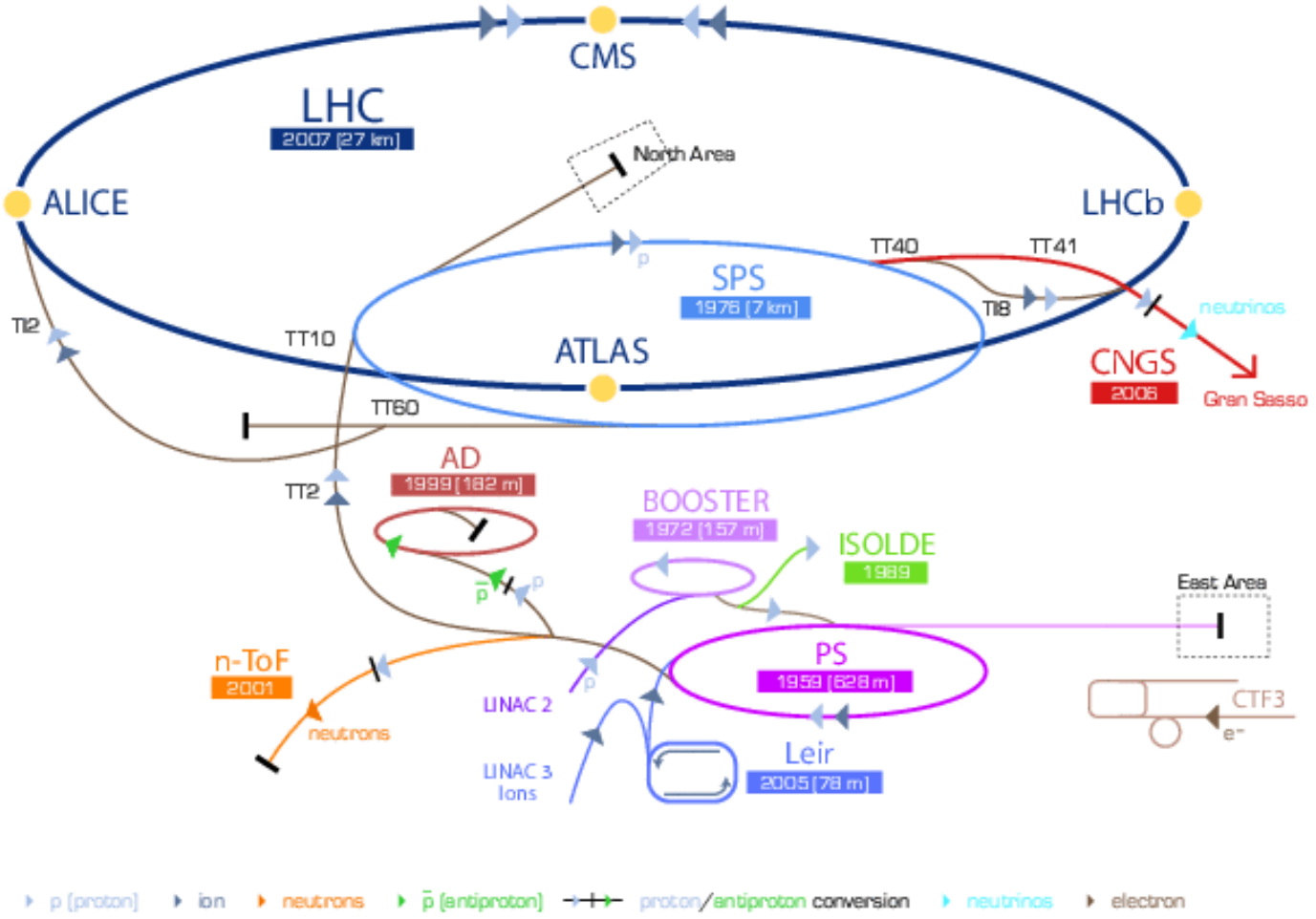
- LHC experiments produce **10-15 million Gigabytes** of data each year (about 20 million CDs!)
- LHC data analysis requires a computing power equivalent to **~100,000 of today's fastest PC processors**.

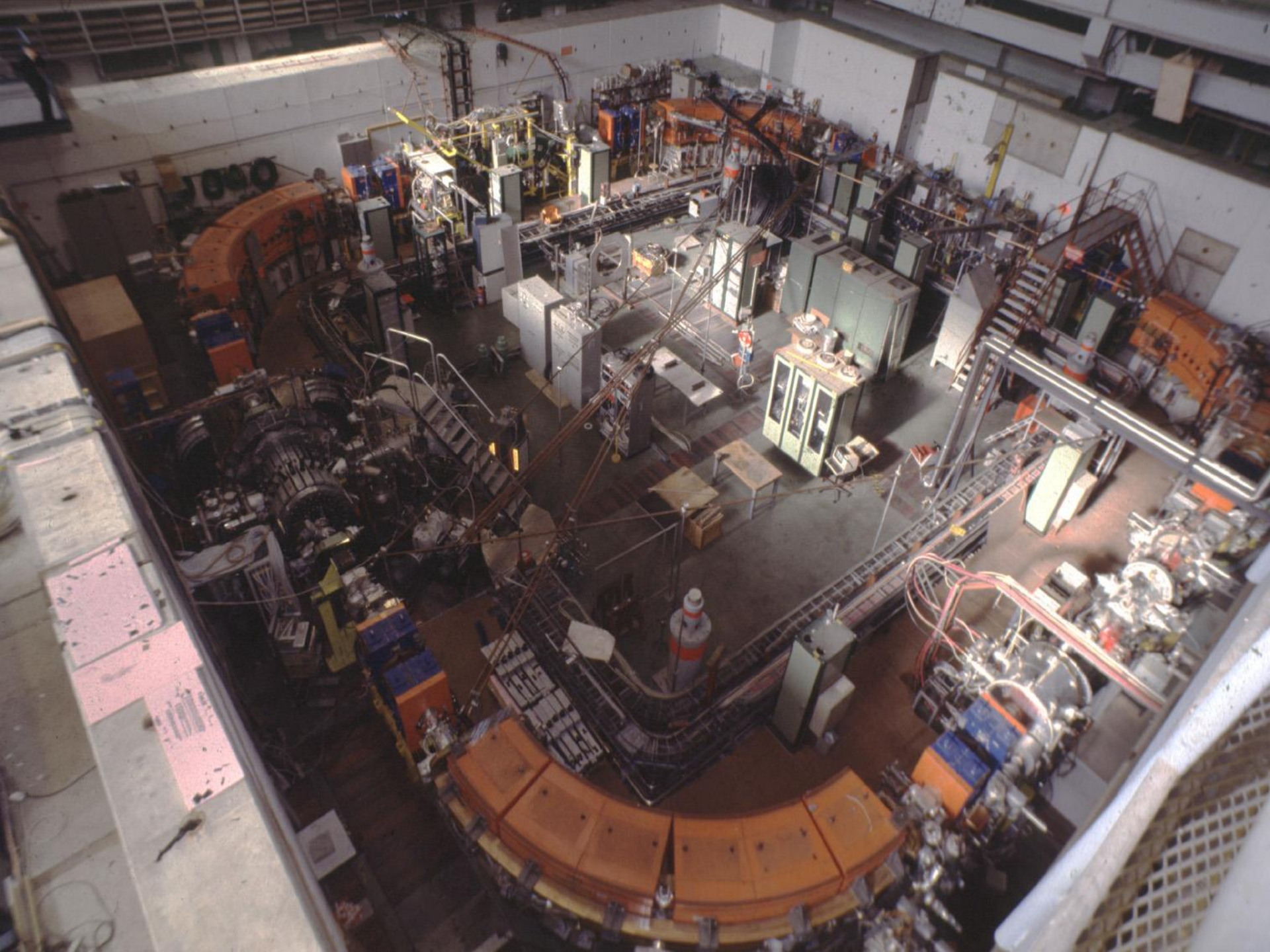
LCG-LHC Computing GRID

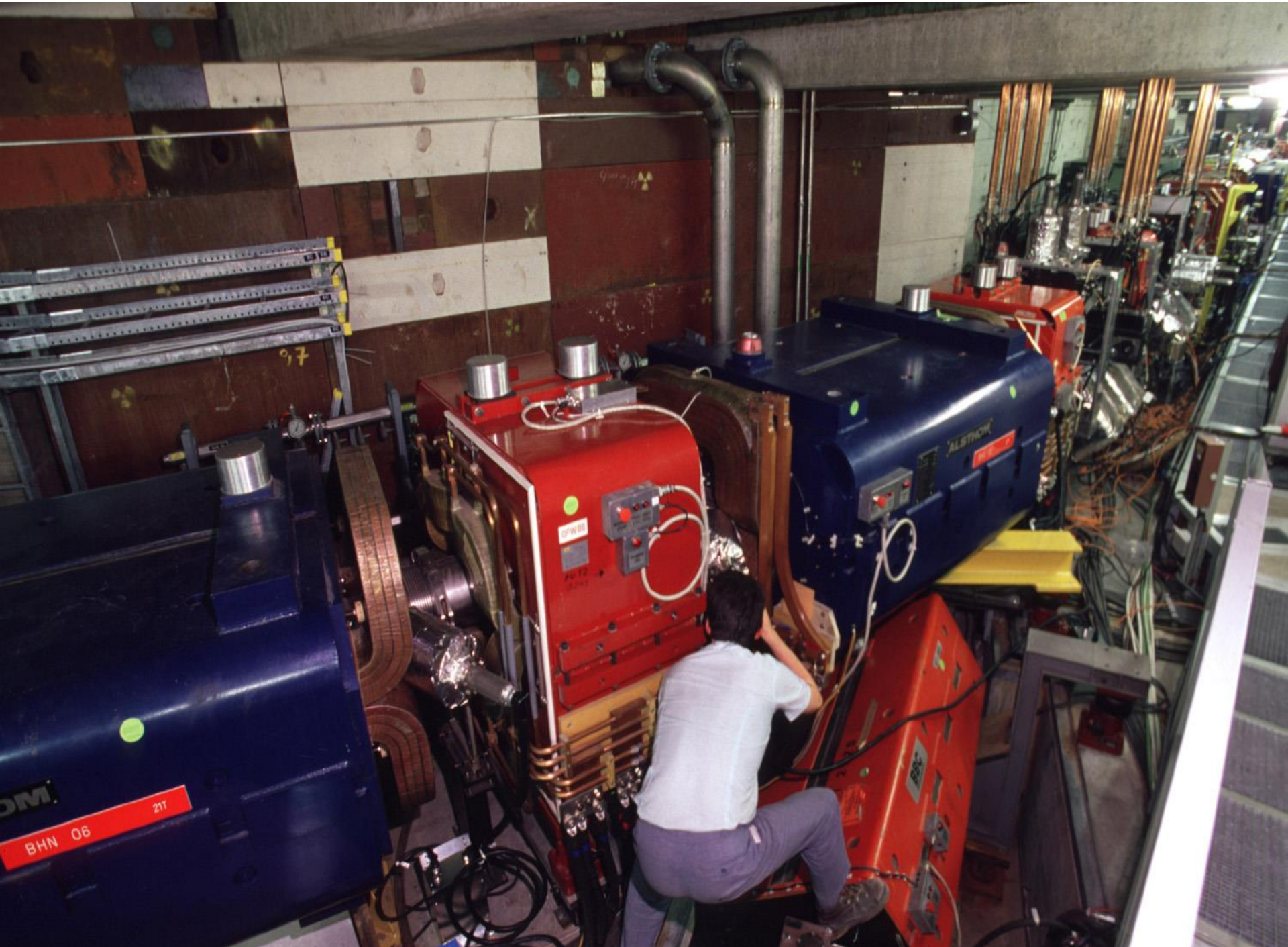



T2s and T1s are inter-connected by the general purpose research networks
Any Tier-2 may access data at any Tier-1
Dedicated 10 Gbit links
CERN
GridKa
IN2P3
TRIUMF
Brookhaven
ASCC
Nordic
Fermilab
CNAF
RAL
SARA
NIKHEF
PIC
T2

CERN – world biggest accelerator complex





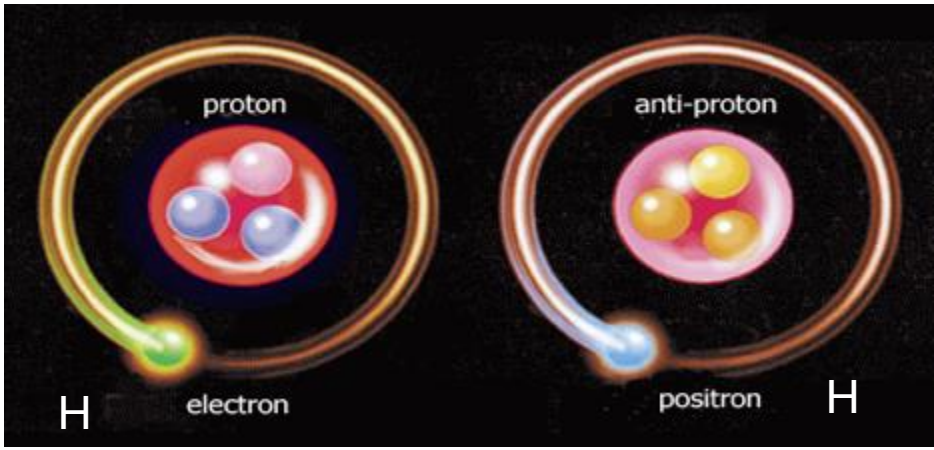

BHN 06
217
ALSTHOM

Antimatter Physics

Matter-Antimatter comparison

Very fundamental in our theory of physics

$m=\bar{m}$ $g=\bar{g}$



ASACUSA
ATRAP
ALPHA

Trapping $\bar{H}$ in a magnetic bottle

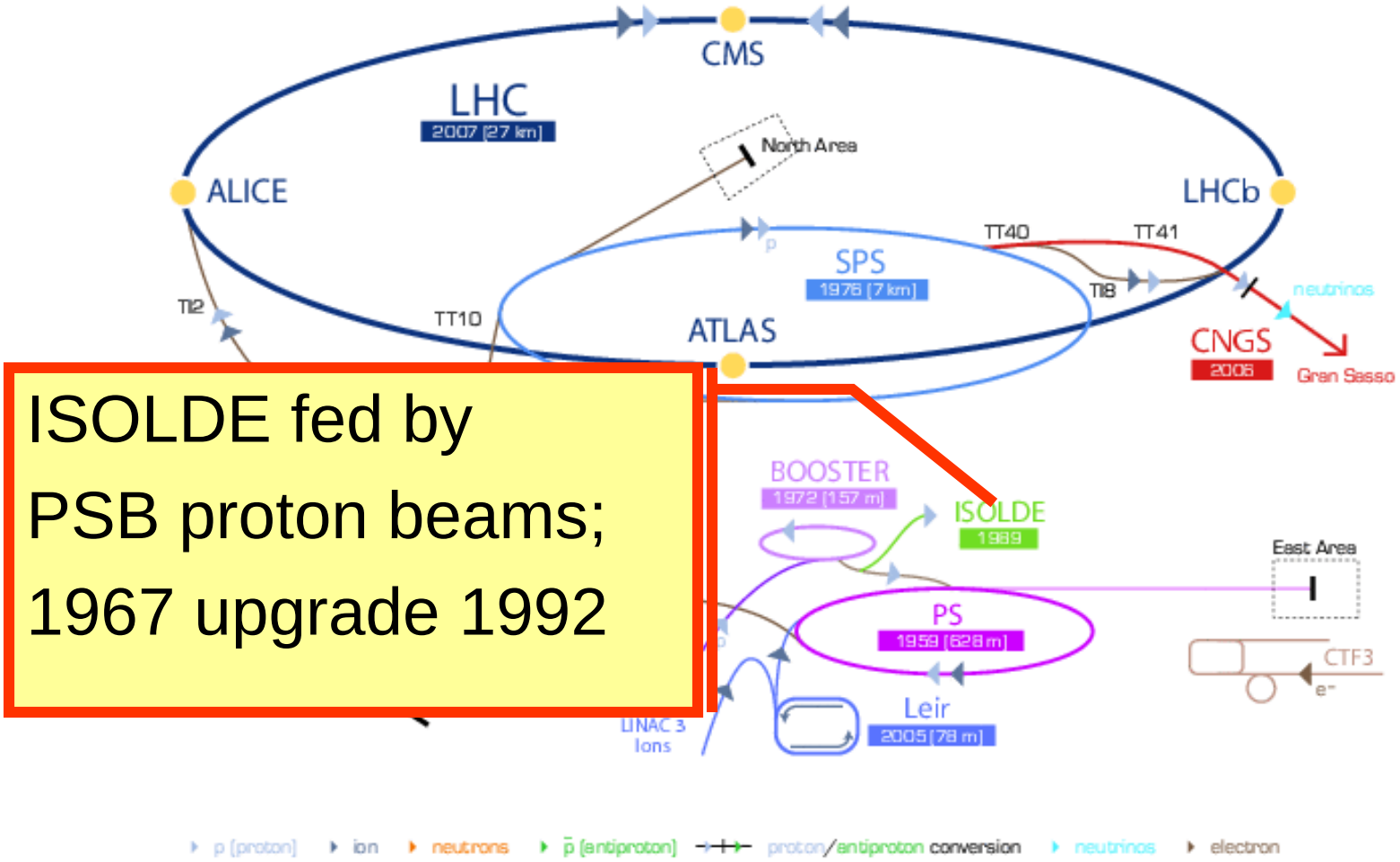
AEGIS

Look at $\bar{H}$ free fall
Galileo's experiment for antimatter !

ACE

Biological effect of $\bar{p}$
Possible use for cancer therapy

CERN accelerator complex,
working not only for LHC

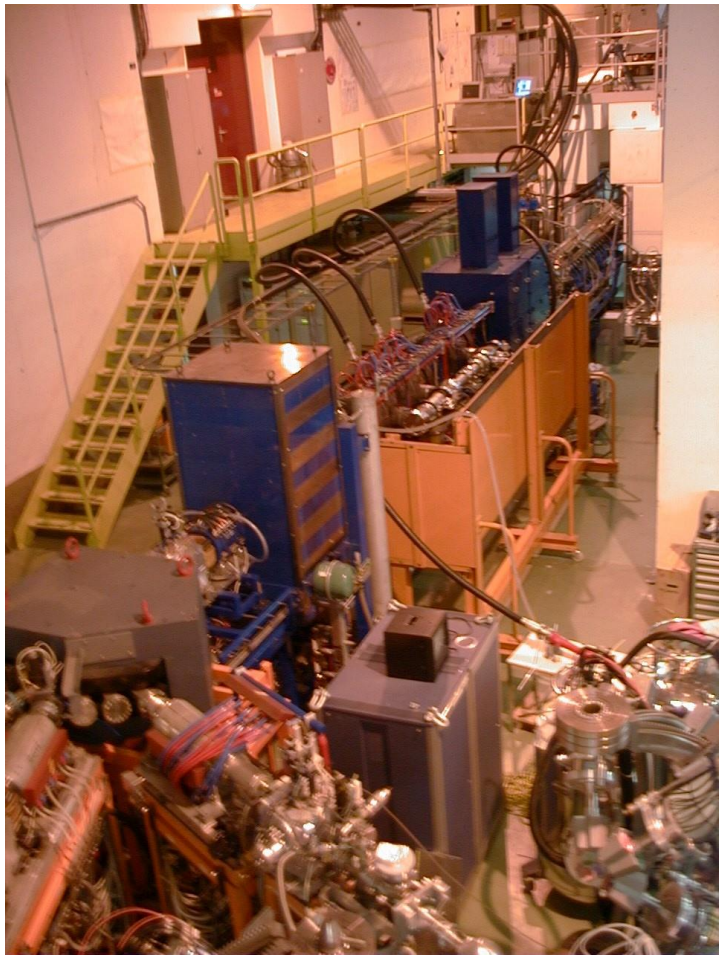


ISOLDE fed by
PSB proton beams;
1967 upgrade 1992

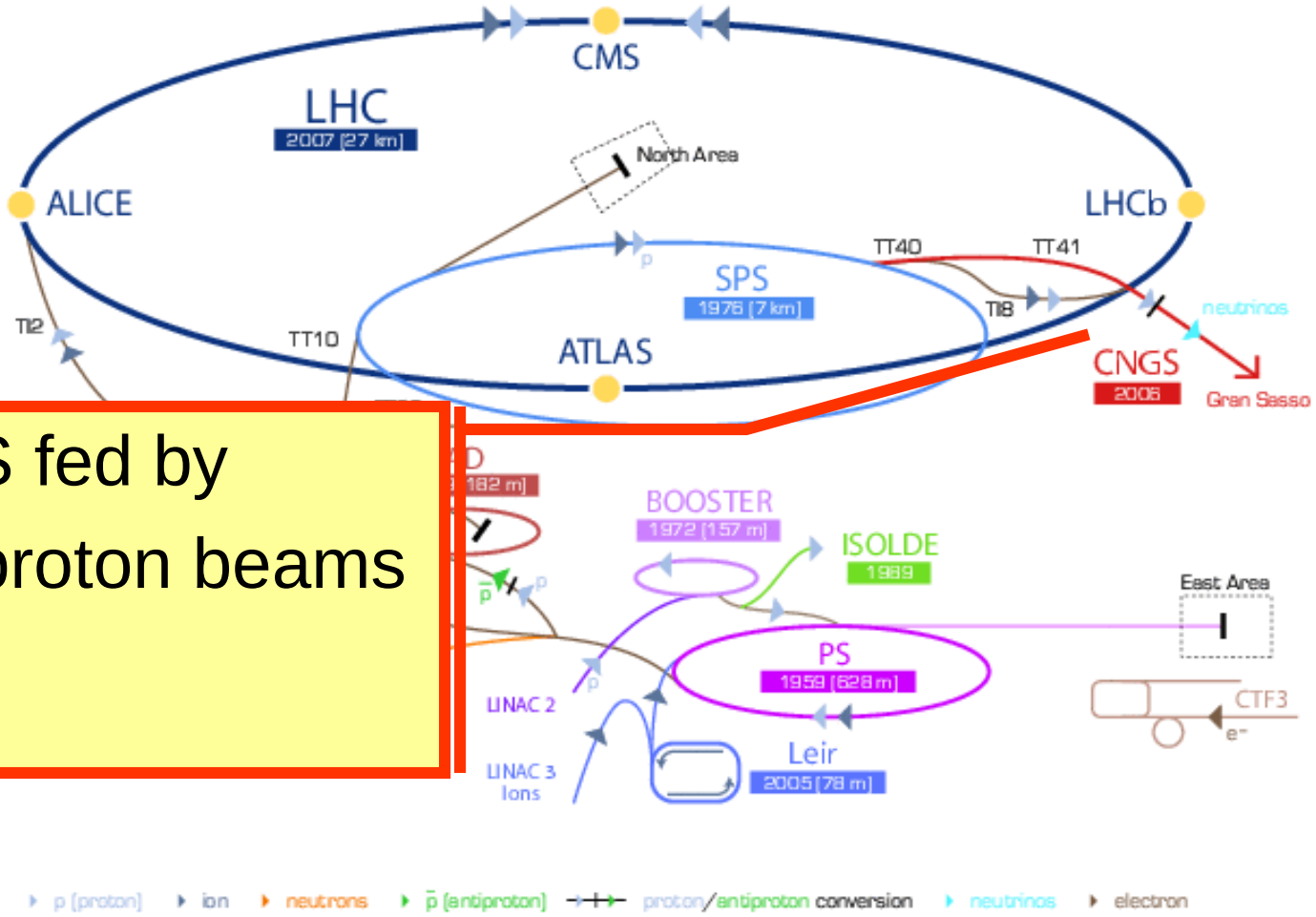
ISOLDE - Isotope Separator On Line, and Radioactive beam EXperiment (REX)

An alchemical factory for nuclear physics

Low-energy beams of radioactive isotopes - atomic nuclei. The facility, located at the Proton-Synchrotron Booster (PSB), is like a small alchemical factory, changing one element to another. It produces a total of more than 1000 different isotopes for a wide range of research.



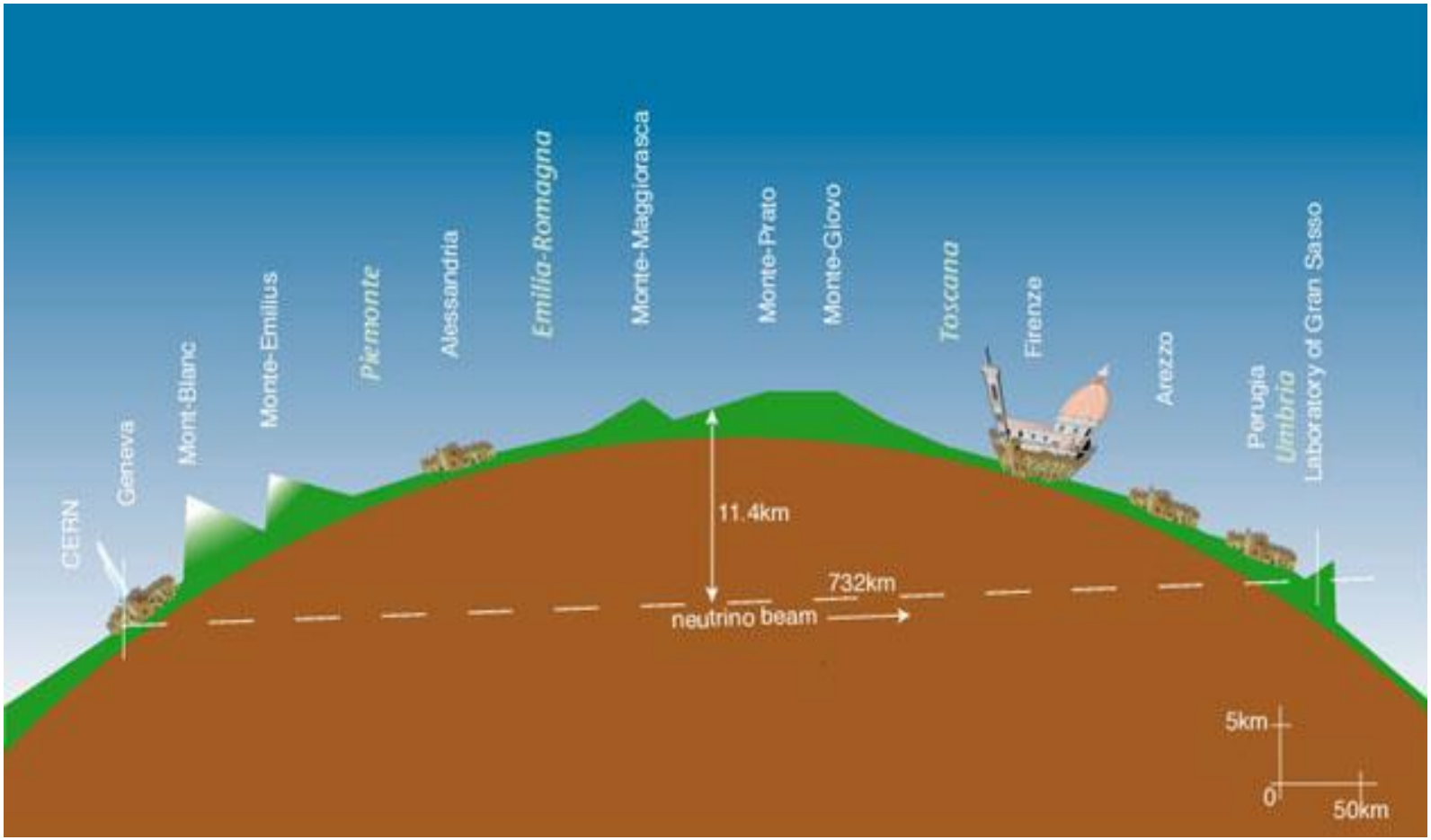
CERN accelerator complex,
working not only for LHC !



CNGS fed by
SPS proton beams

CNGS – CERN Neutrino to Gran Sasso experiment - investigation of the nature of neutrinos

CERN sends muon neutrinos to the Gran Sasso National Laboratory (LNGS), 732 km away in Italy. There, two experiments, OPERA and ICARUS, wait to find out if any of the muon neutrinos have transformed into tau neutrinos. To create the neutrino beam, a proton beam from the Super Proton Synchrotron (SPS) is used.



An experiment on climate

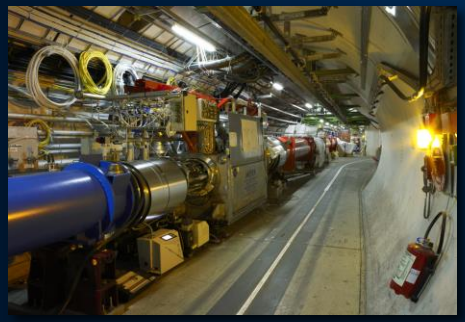
Study effect of cosmic rays on clouds formation
(cosmic rays “simulated “ by T11 beam, clouds created in a large climatic chamber

Innovation
Education
CERN
uniting people
Research

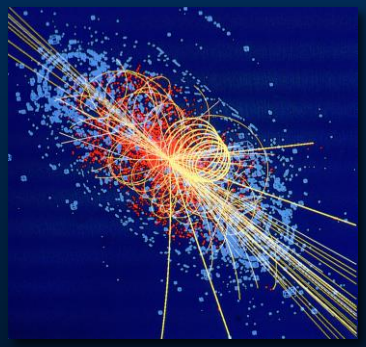
CERN: Particle Physics and Innovation

- Interfacing between fundamental science and key technological developments

- CERN Technologies and Innovation



Accelerating particle beams



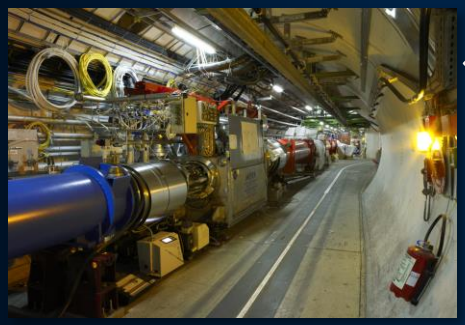
Detecting particles

Large-scale computing (Grid)

CERN

Medical Application as an Example of Particle Physics Spin-off

Combining Physics, ICT, Biology and Medicine to fight cancer

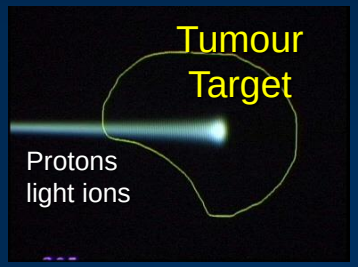


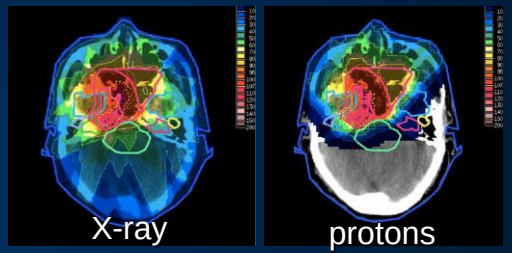
Accelerating particle beams

~30’000 accelerators worldwide

~17’000 used for medicine

Hadron Therapy

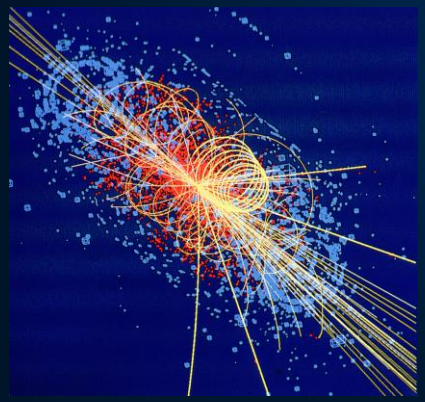




Leadership in Ion Beam Therapy now in Europe and Japan

>70’000 patients treated worldwide (30 facilities)

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

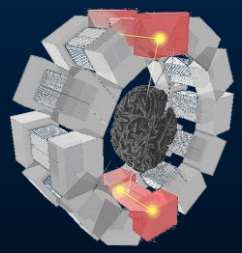


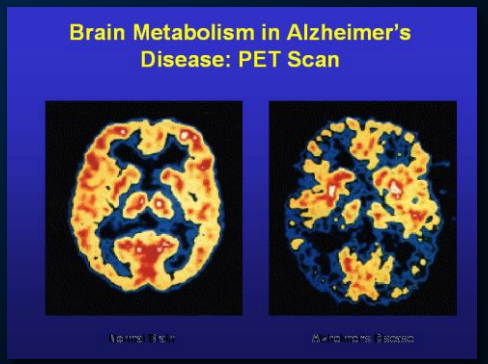
Detecting particles

Imaging

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

PET Scanner





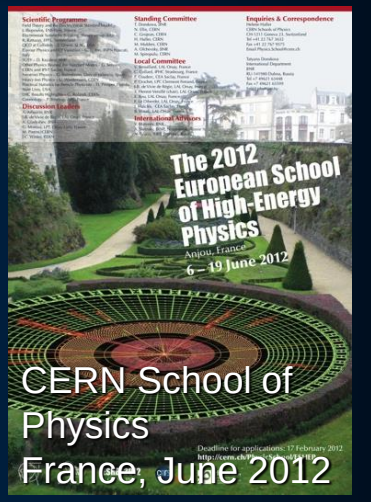
CERN Education Activities

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

Summer Students 2014

Summer Students 2014

MEMBER STATES 149

Austria	3
Belgium	4
Bulgaria	2
Czech Republic	6
Denmark	6
Finland	2
France	15
Germany	21
Greece	9
Hungary	2
Israel	3
Italy	11
Netherlands	10
Norway	5
Poland	5
Portugal	4
Slovakia	3
Spain	11
Sweden	6
Switzerland	4
United Kingdom	17

OBSERVERS 45

India	10
Japan	5
Russia	10
Turkey	7
USA	13

CANDIDATE FOR ACCESSION

Romania	2
Serbia	2

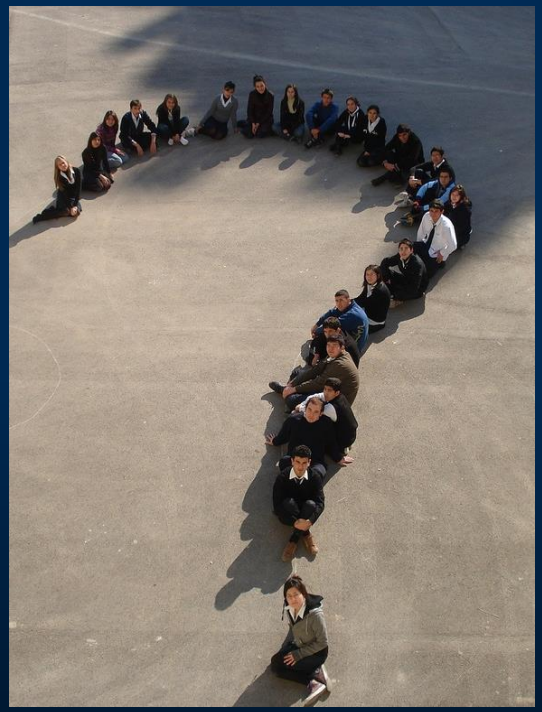
4

OTHERS

Albania	1	Cameroun	1	Estonia	5	Lithuania	4	Senegal	1	U.A.E.	2
Algeria	3	Canada	3	Georgia	1	Malaysia	4	Singapore	1	Venezuela	1
Argentina	1	China	8	Ghana	1	Malta	3	Slovenia	1		
Australia	1	Colombia	1	Indonesia	2	Mexico	1	South Africa	2		
Bangladesh	1	Costa Rica	2	Iran	3	Nepal	1	Swaziland	1		
Belarus	1	Croatia	1	Ireland	1	Pakistan	3	Syria	1		
Bolivia	1	Cyprus	2	Korea, South	1	Palestine	1	Thailand	4		
Bosnia	1	Ecuador	3	Latvia	1	Philippines	1	T.F.Y.R.O.M.	2		
Brazil	1	Egypt	5	Lebanon	2	Puerto Rico	1	Ukraine	4		

93

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.

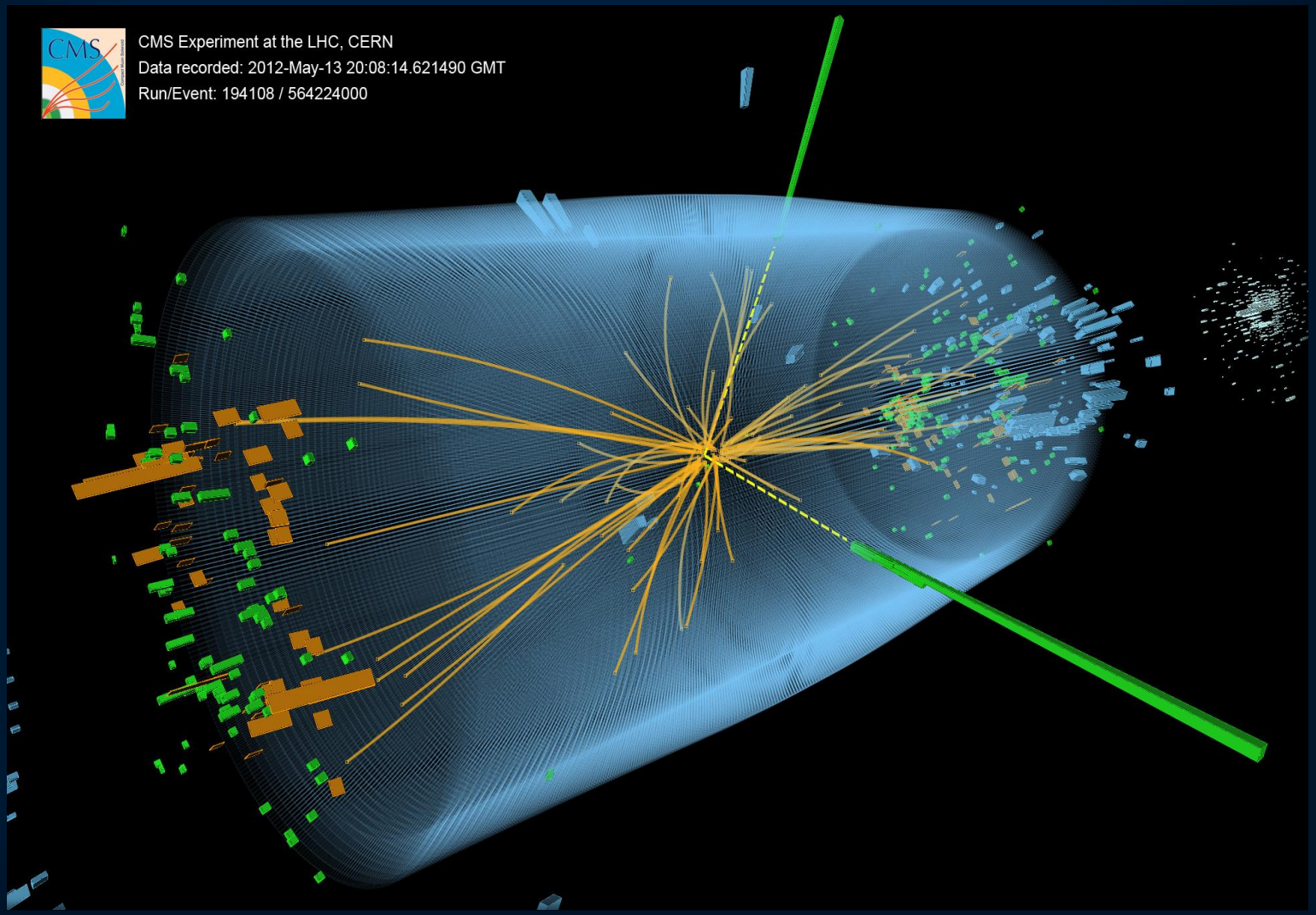
Their results are based on the analysis of considerably more data than those presented at the summer conferences, sufficient to make significant progress in the search for the Higgs boson, but not enough to make any conclusive statement on the existence or non-existence of the elusive Higgs.

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.

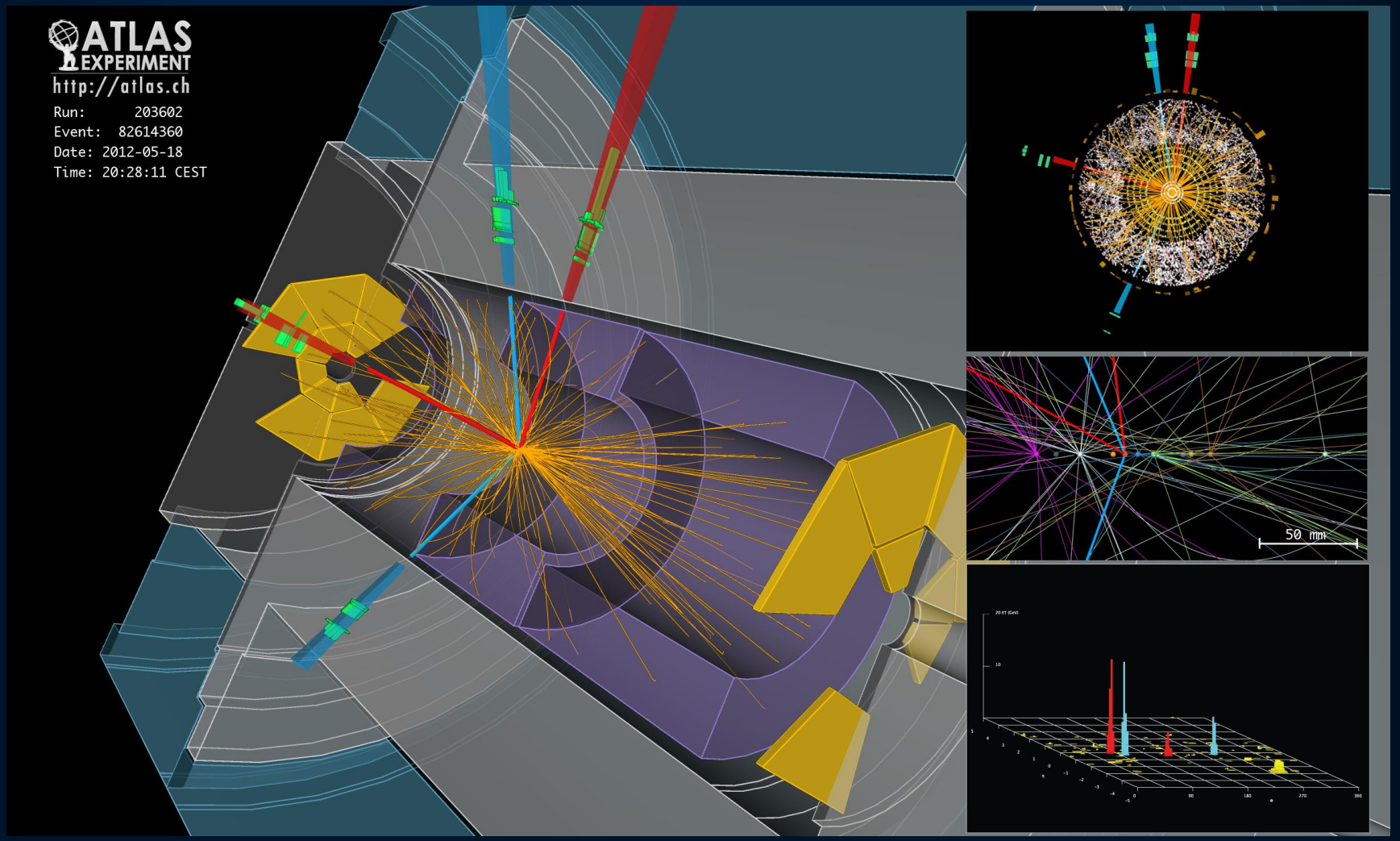
4 July 2012: CERN press conference

“CERN experiments observe particle consistent with long-sought Higgs boson”



4 July 2012: CERN press conference

“CERN experiments observe particle consistent with long-sought Higgs boson”



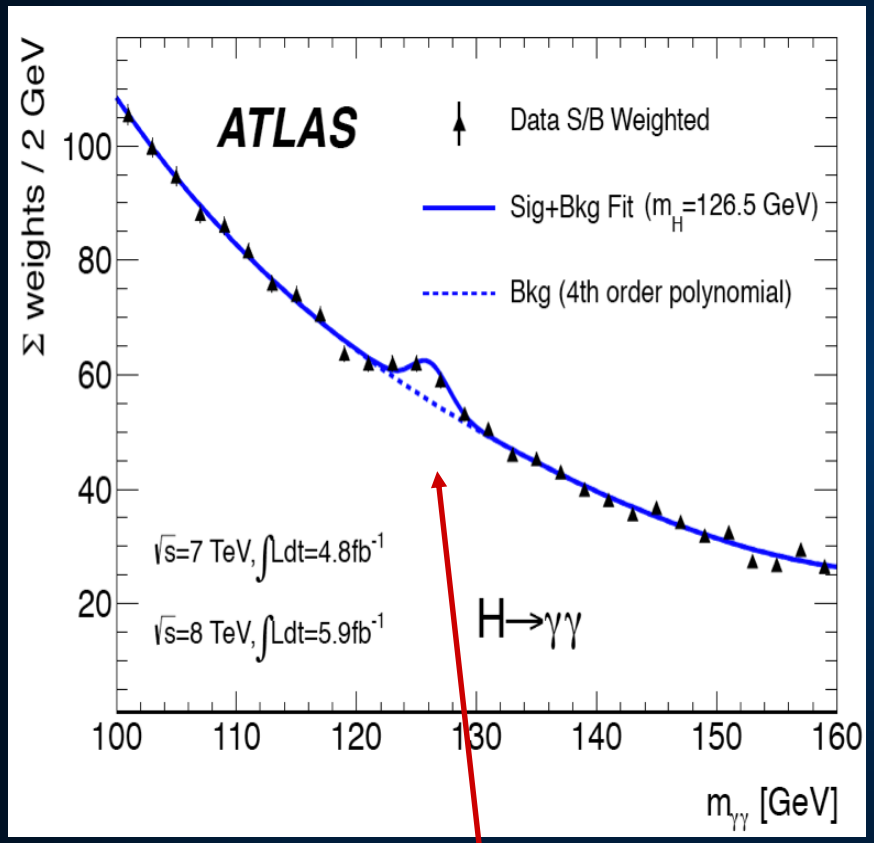
CERN experiments observe particle consistent with long-sought Higgs boson
Geneva, 4 July 2012.

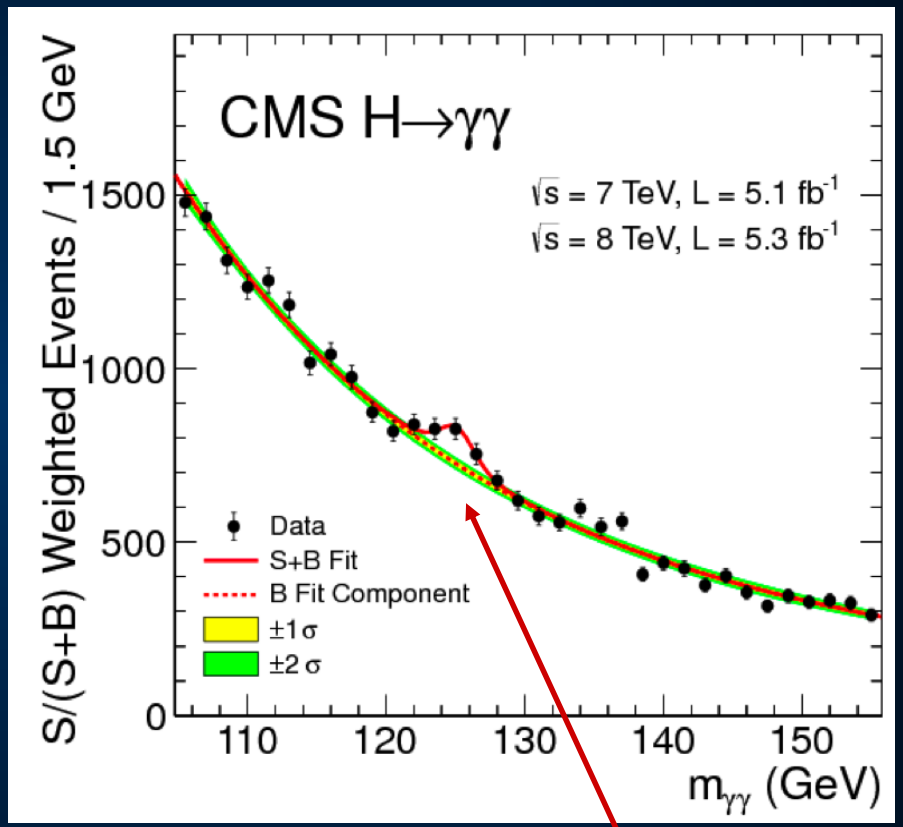
At a seminar held at CERN[1] today as a curtain raiser to the year's major particle physics conference, ICHEP2012 in Melbourne, the ATLAS and CMS experiments presented their latest preliminary results in the search for the long sought Higgs particle. **Both experiments observe a new particle in the mass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

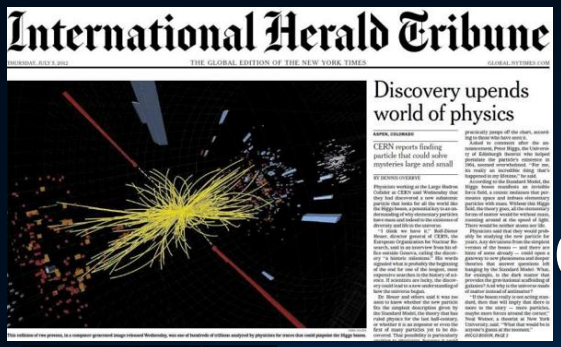
Higgs decay to $\gamma\gamma$, ATLAS and CMS, summer 2012 data

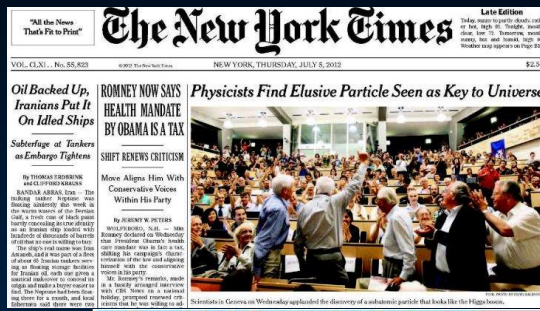




July 4th at CERN, after the Higgs seminar

4 JULY 2012
CERN Press conference


International Herald Tribune
THE GLOBAL EDITION OF THE NEW YORK TIMES
Discovery upends world of physics
CERN reports finding particle that could solve mysteries large and small


The New York Times
Late Edition
Oil Backed Up, Iranians Put It On Idled Ships
Subterfuge at Tankers as Embargo Tightens
ROMNEY NOW SAYS HEALTH MANDATE BY OBAMA IS A TAX
SHIFT RENEWS CRITICISM
Move Aligns Him With Conservative Voices Within His Party
Physicists Find Elusive Particle Seen as Key to Universe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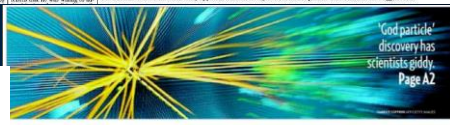
A giant leap for science
Finding the Higgs boson


ヒッグス粒子 発見か
新素粒子検出 年内に結論
日米欧2チーム


EDIÇÃO LISBOA QUI 5 JUL 2012
Por dia, Deco recebe 87 casos por causa de sobreendividamento p14
HOJE: HERÓIS MARVEL
Milhares de moradores de bairros sociais em risco de perderem RSI
A mudança está a passar despercebida, mas deve afectar milhares de beneficiários de RSI que vivem em habitações de renda apoiada, morar numa casa camarária é uma forma de rendimento Portugal, 12
Ministério de Portas contrata funcionário de CDS-PP
Lusófona diz que Relvas deu todos os dados para ter curso
CIÊNCIA "PARTÍCULA DE DEUS" EXISTE. MAS A HISTÓRIA NÃO ACABA AQUI


Spécial Festival d'Avignon
La 66e fête du théâtre démarre le 7 juillet
Le Monde
Le Monde des livres
Les coups de cœur de la rédaction
Science : la matière dévoilée
Le boson de Higgs, particule manquante pour expliquer l'Univers, vient d'être découvert
Les physiciens du CERN de Genève ont prouvé son existence à 99,9999 %
IMPÔTS CE QUI VA CHANGER
7,2 milliards de plus dès 2012
Réforme fiscale à l'automne
ALGÉRIE L'INDÉPENDANCE
Une fête sans panache
La souffrance, mais pas de haine
Ces livres qui explorent l'histoire


'God particle' discovery has scientists giddy.
Page A2


The Gazette
MONTREAL | THURSDAY, JULY 5, 2012 | SINCE 1778 | BREAKINGNEWS.ATMONTREALGAZETTE.COM
EL PAIS
EL PERIÓDICO GLOBAL EN ESPAÑOL
A solas con la prueba del VIH
De Villota pierde el ojo derecho
Pistorius estará en los Juegos
Hallada la partícula clave para a comprensión del universo
La Audiencia Nacional imputa a toda la cúpula de Bankia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«КРЕМЛЕВСКИЕ» САМОЛЕТЫ ПРИШЛОСЬ МЕНЯТЬ НА ПЕРЕПРАВЕ
МЕТРО СПУСТЯТ НА ВОДУ


AD
ALGEMEEN DAGBLAD
donderdag 5 juli 2012
EINDELIJK GELIJK NA 48 JAAR
Zieke Kaj en zijn moeder toch samen in de VS
SPORTWERELD VAN PERSIE


Frankfurter Allgemeine
ZEITUNG FÜR DEUTSCHLAND
Fünf Tote bei Geiselnahme in Karlsruhe
Masse macht's
Große Mehrheit im


CHINA DAILY
THURSDAY, July 5, 2012
chinadaily.com.cn
IMPORTANT MATTER
Scientists claim to have discovered 'God particle'
DANGEROUS MOVE
Freeing captured animals may lead to disasters
MOVIE PLOT
Iron Man film company looks to China for screen success


THE TIMES OF INDIA
UNDER FIRE FROM OPPN, AKHILESH ROLLS BACK CAR BONANZA FOR MLAS
ADJUSTING DIESEL PRICE BETTER THAN TAXING CARS, SAYS MONTEK
BLADE RUNNER PISTORIUS SET FOR OLYMPIC HISTORY: TO RUN 400M & RELAY
Big bang moment: Scientists may have found 'God particle'
Adarsh scam: Finally, CBI charges sheets 13


THE HINDU
INDIA'S NATIONAL NEWSPAPER SINCE 1878
RARE CHOLA INSCRIPTIONS
MAY HAVE BEEN POISONED
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RAHANE RETURNS
Elusive particle found, looks like Higgs boson
CERN physicists hail evidence of game-changing discovery of subatomic particle


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Società scientifica
La particella che può svelare i segreti dell'universo
UN'AZIENDA IN OSTAGGIO


gazeta
WYBORCZA.PL
Ukraińcy biją się o język. Rosyjski
Cząstkę Higgsa fizycy najpierw wymyślili, potem szukali 40 lat
BOSKA MASA
Po tym odkryciu świat już nigdy nie będzie taki sam.


আনন্দবাজার পত্রিকা
বিজ্ঞানের 'ঈশ্বর' দর্শন
সত্যেন্দ্রনাথকে বিনম্র প্রণাম
'পেয়েছি, যা খুঁজছিলাম'

Peter Higgs and Francois Englert