

# Украинская программа для учителей физики 2013

Добро пожаловать в ЦЕРН  
вводная лекция



Marina Savino



# Who are we?

## The Name

**CERN:** Conseil Européen pour la Recherche Nucléaire

CERN – European Organisation for Nuclear Research

We are an International Organisation (like UN, WHO, etc)

CERN was founded 1954: 12 European States

Today: 20 member states

1945 Europe is getting out of two  
devastating wars in less than 30 years



All researchers leave Europe for the USA or Russia

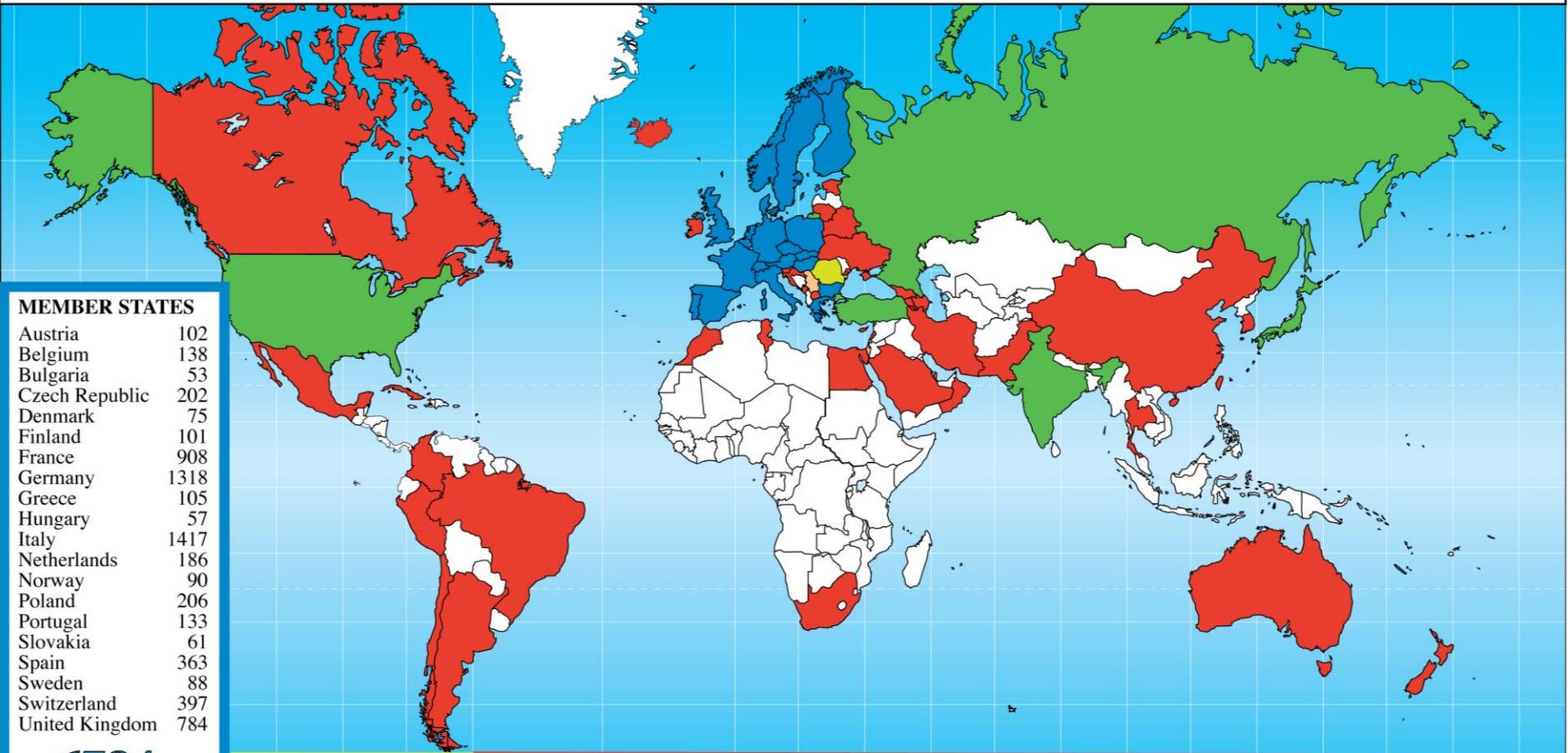
- **Member States:**
- **Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.**
- **Romania** is a Candidate for Accession to Membership of CERN:
- **Israel** and **Serbia** are Associate Members in the pre-stage to Membership of CERN
- **Applicant States: Cyprus, Slovenia, Turkey**
- **Associate Members: Ukraine**
- **Observers to Council: India, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO**



~ 2300 staff  
~ 1050 other paid personnel  
> 11000 users

Budget (2012) ~1000 MCHF

# Distribution of All CERN Users by Nation of Institute on 4 April 2012



## MEMBER STATES

Austria	102
Belgium	138
Bulgaria	53
Czech Republic	202
Denmark	75
Finland	101
France	908
Germany	1318
Greece	105
Hungary	57
Italy	1417
Netherlands	186
Norway	90
Poland	206
Portugal	133
Slovakia	61
Spain	363
Sweden	88
Switzerland	397
United Kingdom	784

**6784**

## OBSERVERS

India	134
Japan	225
Russia	859
Turkey	83
USA	1749

**3050**

## CANDIDATE FOR ACCESSION

Romania	78
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## ASSOCIATE MEMBER IN THE PRE-STAGE TO MEMBERSHIP

Israel	67
Serbia	26

## OTHERS

Argentina	18	China	115	Iran	16	Oman	1	Ukraine	21
Armenia	13	China (Taipei)	70	Ireland	10	Pakistan	22	Uzbekistan	1
Australia	28	Colombia	10	Korea	91	Peru	2		
Azerbaijan	1	Croatia	21	Lebanon	1	Qatar	1		
Belarus	22	Cuba	4	Lithuania	13	Saudi Arabia	3		
Brazil	102	Cyprus	9	Malta	1	Slovenia	38		
Canada	170	Egypt	7	Mexico	43	South Africa	21		
Chile	4	Estonia	17	Montenegro	1	Thailand	5		
		Georgia	10	Morocco	6	T.F.Y.R.O.M.	2		
		Iceland	3	New Zealand	11	Tunisia	1		

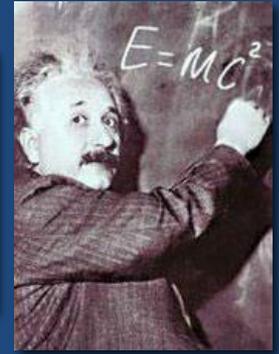
**934**



# The Mission of CERN

**Push back** the frontiers of knowledge

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



**Develop** new technologies and detectors

Information technology  
Medicine - diagnosis



**Train** scientists



**CERN**  
uniting people



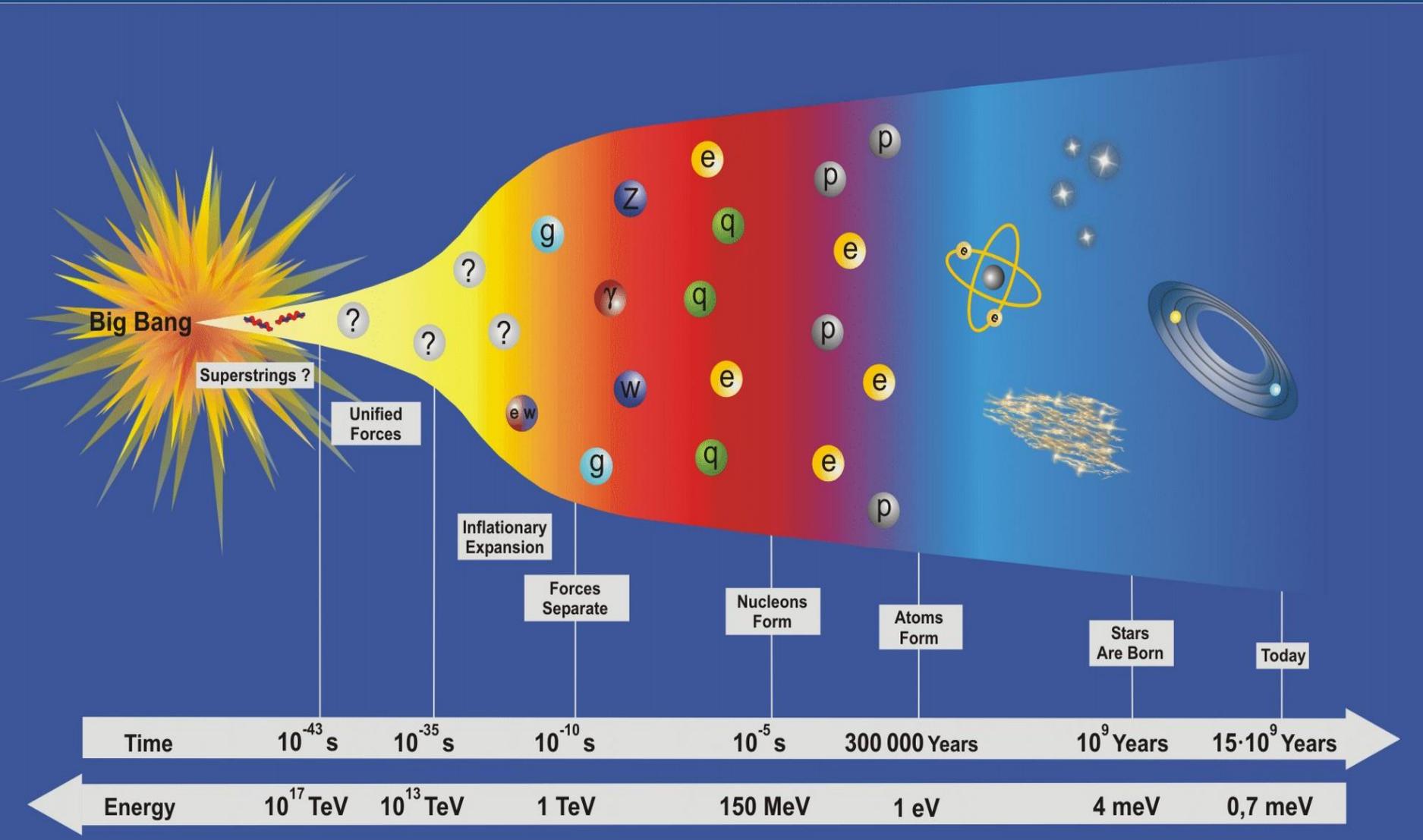
**Unite** people from different countries and cultures

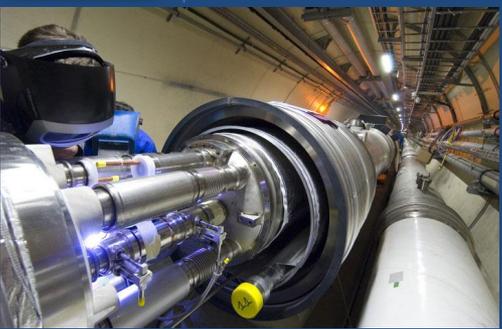
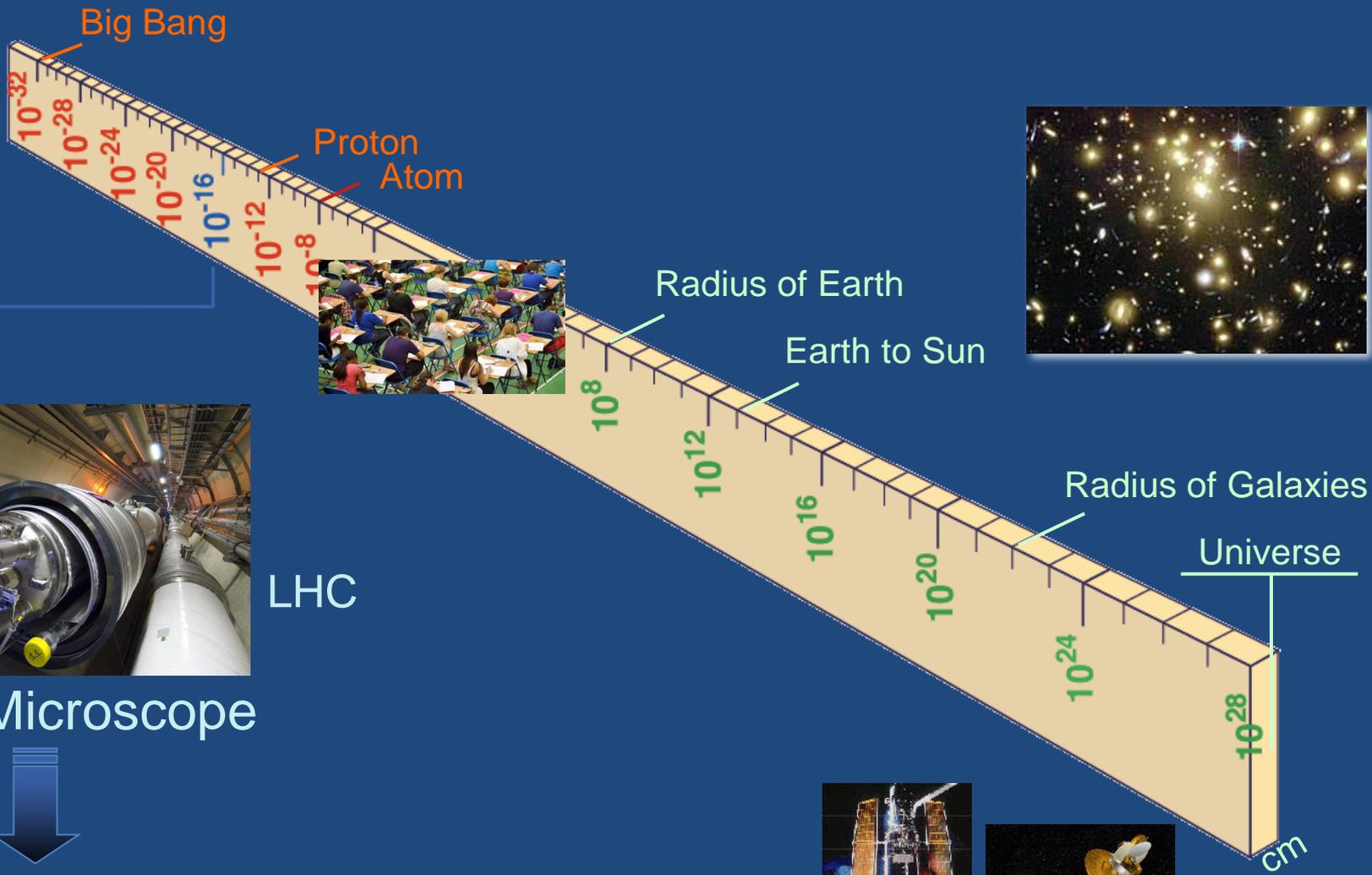
**Research**



**What do we know?**

# How the world started





LHC

## Super-Microscope



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



# What holds the world together

- **Gravitation**

- Apples fall from trees down to earth
- Earth moves in circles around sun
- Remarkable achievement from Newton:  
Gravitation is responsible for both effects



- **Electromagnetic force** explains

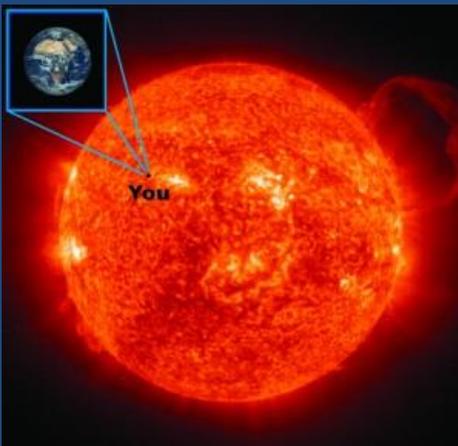
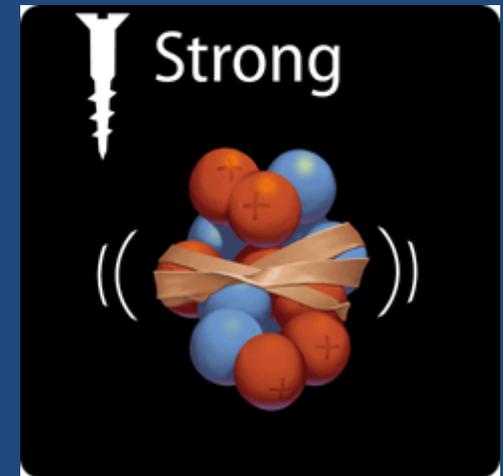
- Electric currents
- Magnets
- All chemistry and therefore biology



# What holds the world together

- **Strong force**

- Holds the atomic nucleus together
- Nuclear force is only one (of many) consequences of the strong force



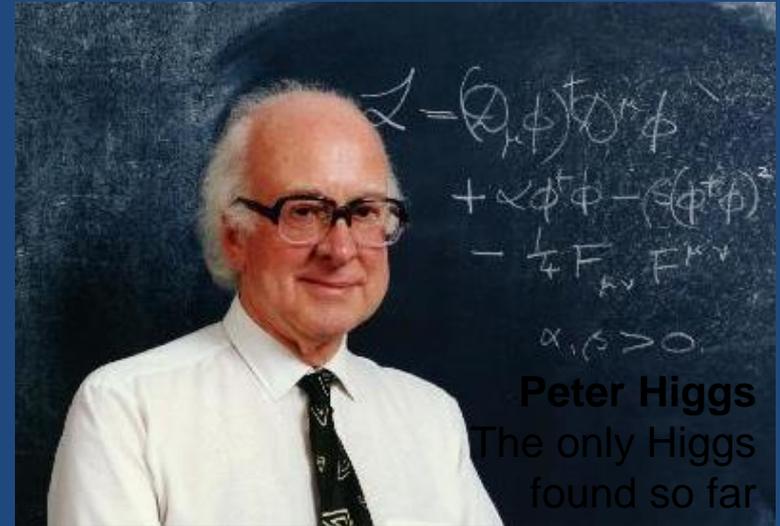
- **Weak force**

- Responsible for the decay of the neutron
- The sun wouldn't burn without the weak force and hence: we wouldn't live!

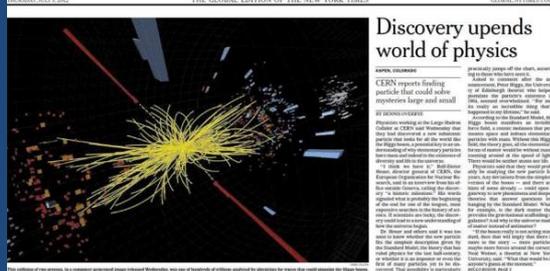
# Riddles and Open Questions

- Many open questions remain.
  - Where does the mass of the particles come from?
  - The so-called Higgs particle could be a solution.
- We only understand what 5% of the universe is made of, the rest is dark matter and dark energy
- What are these?

We hope to find answers to these fundamental questions soon at the Large Hadron Collider

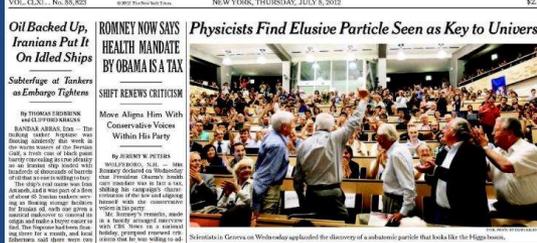


4 JULY 2012 CERN Press conference



Discovery upends world of physics

CERN reports finding particle that could solve mysteries large and small



Scientists at Cern on Wednesday applauded the discovery of a subatomic particle that looks like the Higgs boson.



Physicists Find Elusive Particle Seen as Key to Universe

The Economist: 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

Milhares de moradores de bairros sociais em risco de perderem RSI

Le Monde: Science : la matière dévoilée

The Gazette: EL PAIS

MK: ПОСЛЕДНИЙ КИРПИЧ В СТЕНУ МИРОЗДАНИЯ

AD ALGEMEEN DAGBLAD: EENDELIJK BELIJK NA 48 JAAR

Frankfurter Allgemeine: Masse macht's

China Daily: CHINADAILY

THE HINDU: Elusive particle found, looks like Higgs boson

CORRIERE DELLA SERA: La particella che può svelare i segreti dell'universo

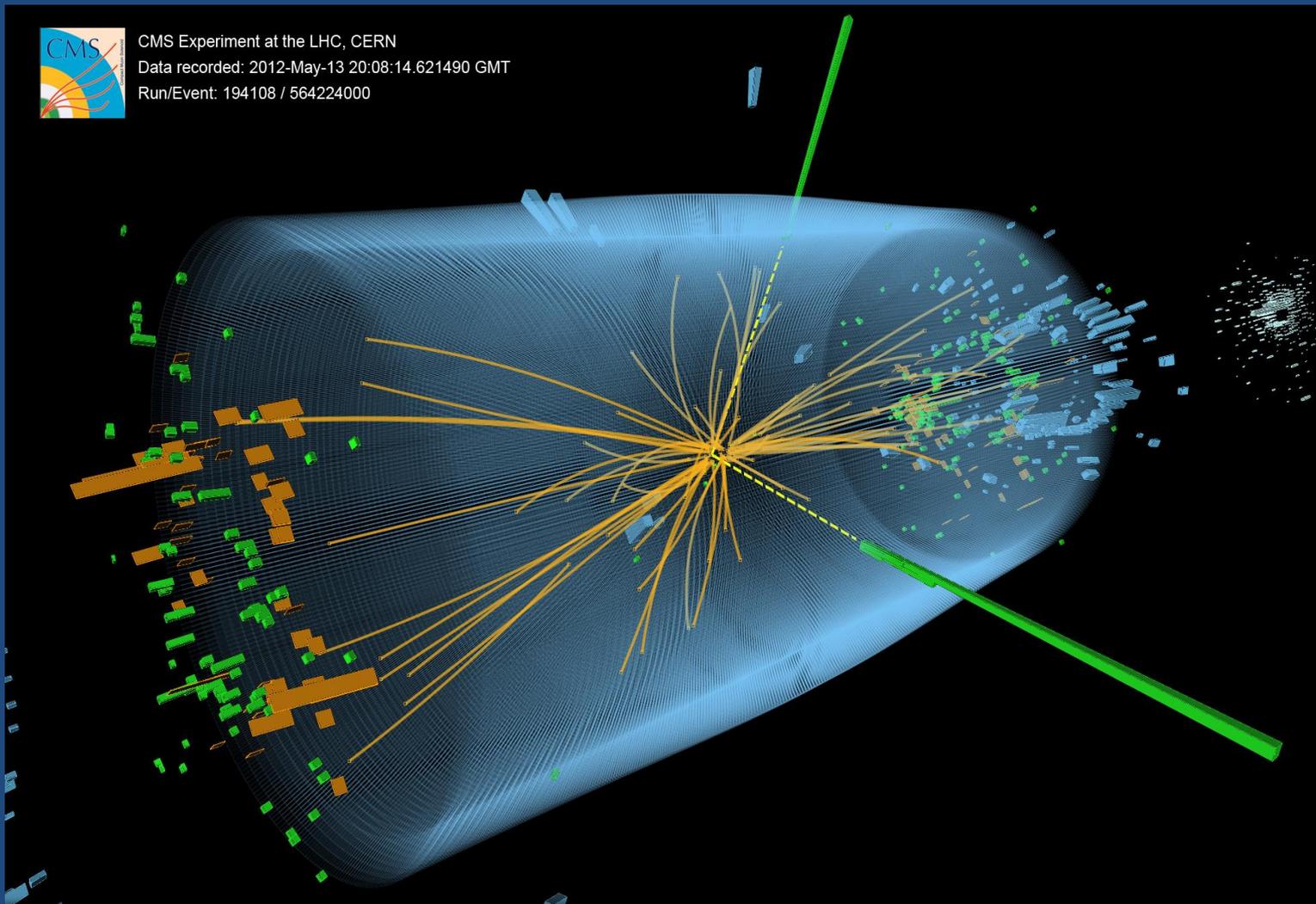
gazeta: Cząstke Higgsa fizycy najpierw wymyślili, potem szukali 40 lat

THE TIMES OF INDIA: Big bang moment: Scientists may have found 'God particle'

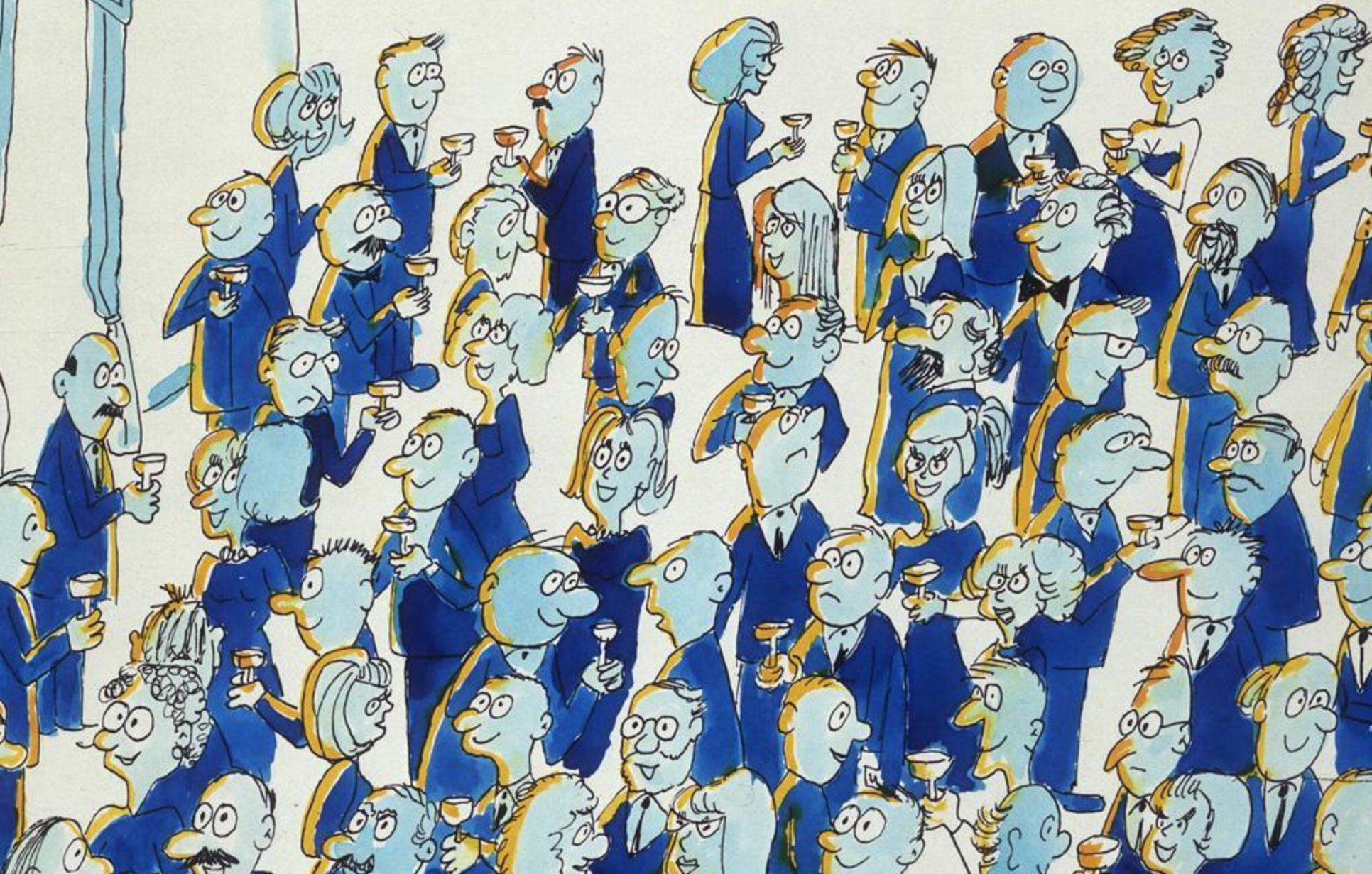
বিশ্বনাথের 'ঈশ্বর' দর্শন

# 4 July 2012: CERN press conference

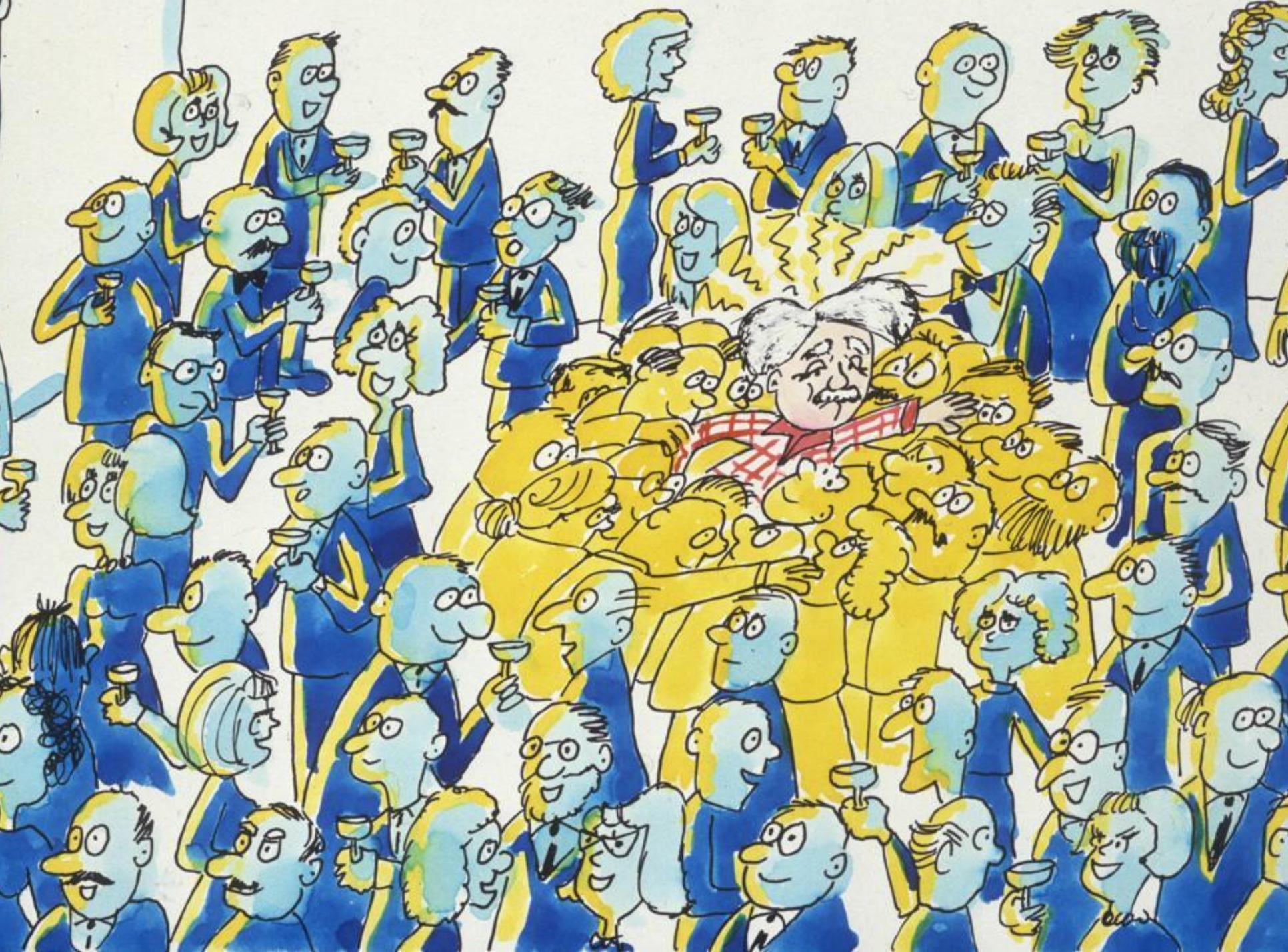
## “CERN experiments observe particle consistent with long-sought Higgs boson”



# The Higgs Mechanism







## How do we do it?

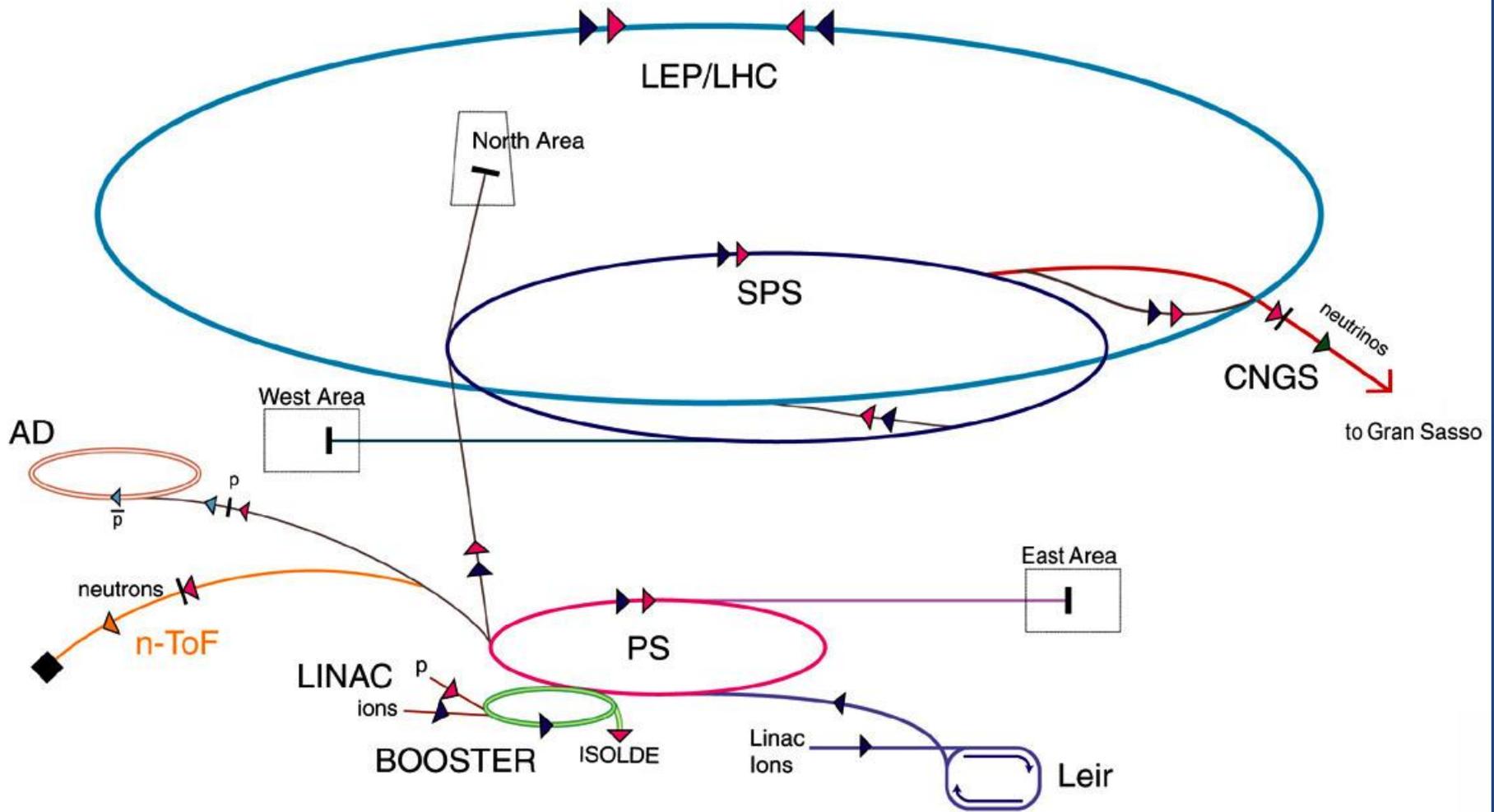
**Accelerators:** Put lots of energy into particles

**Colliders:** Turn energy into matter:  $E = mc^2$

**Detectors:** Identify and measure particles

**Computers:** Analyse and understand what happened

# Accelerator chain at CERN



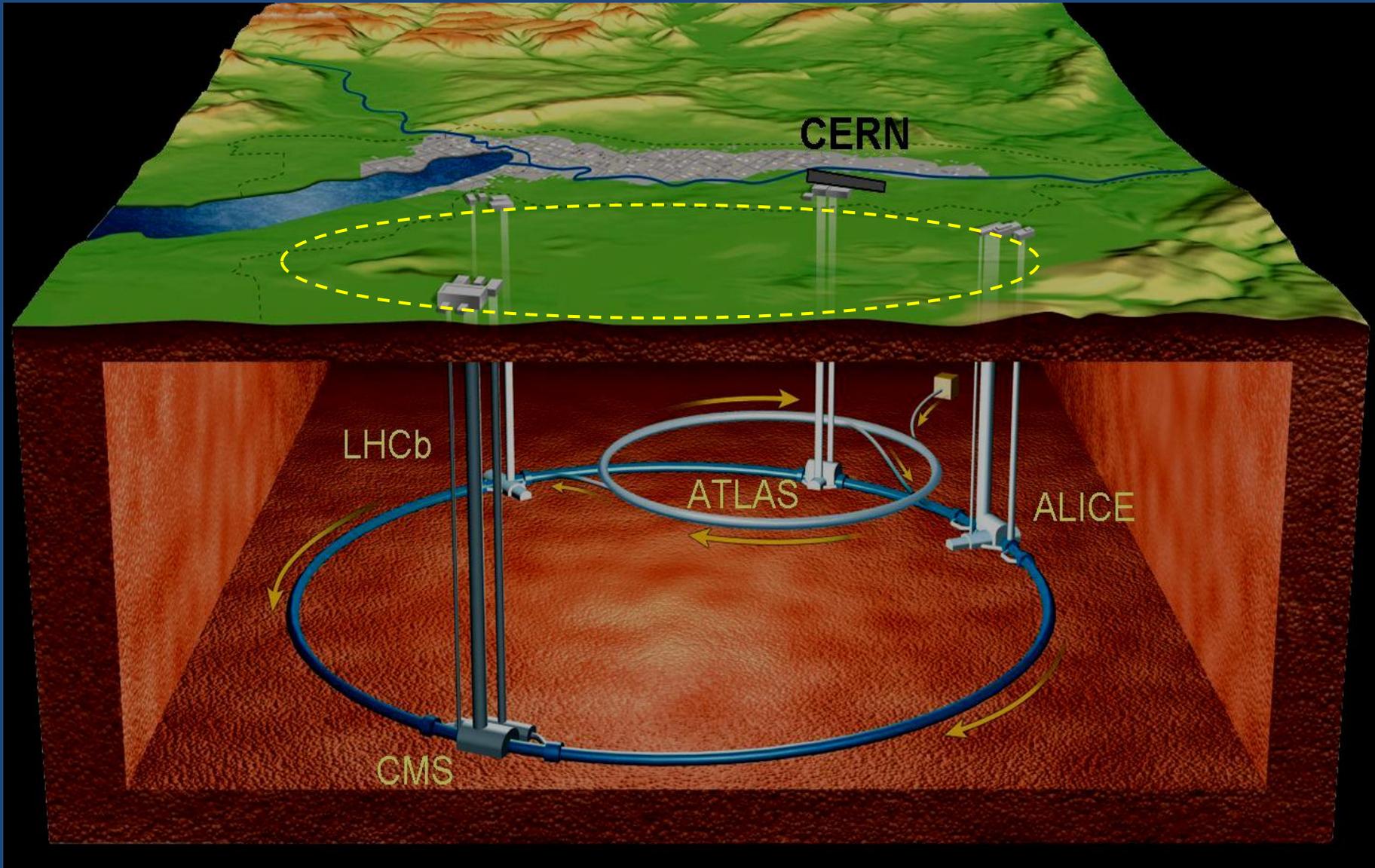
▶ p (proton)  
▶ ion  
▶ neutron  
▶  $\bar{p}$  (antiproton)  
▶  $\leftrightarrow$  proton/antiproton conversion  
▶ neutrino

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



# LHC – Large Hadron Collider



# The Large Hadron Collider (LHC)

Proton-Proton Collider

7 TeV +7 TeV

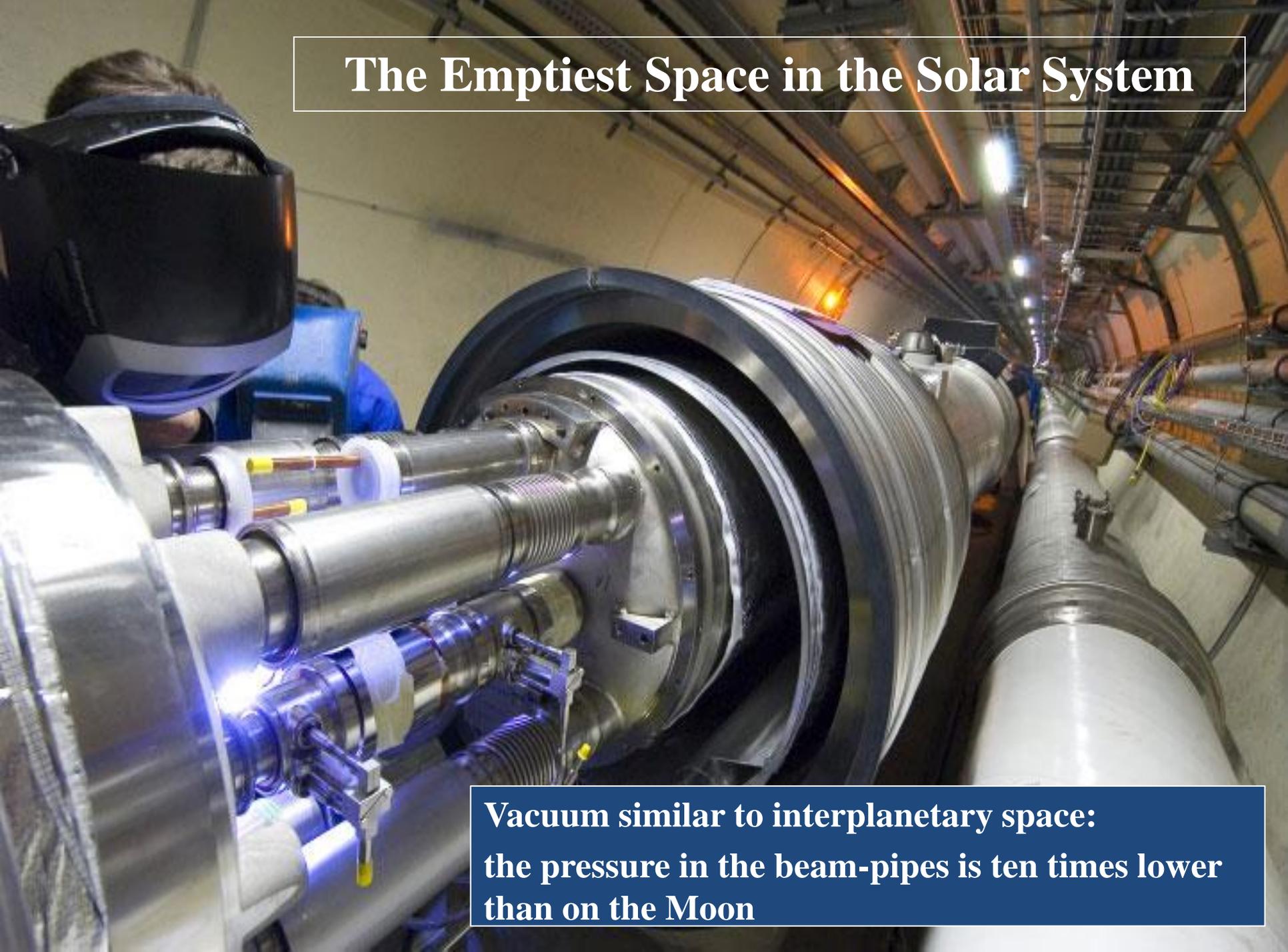


1,000,000,000 collisions/second

Primary targets:

- Origin of mass
- Nature of Dark Matter
- Primordial Plasma
- Matter / Antimatter

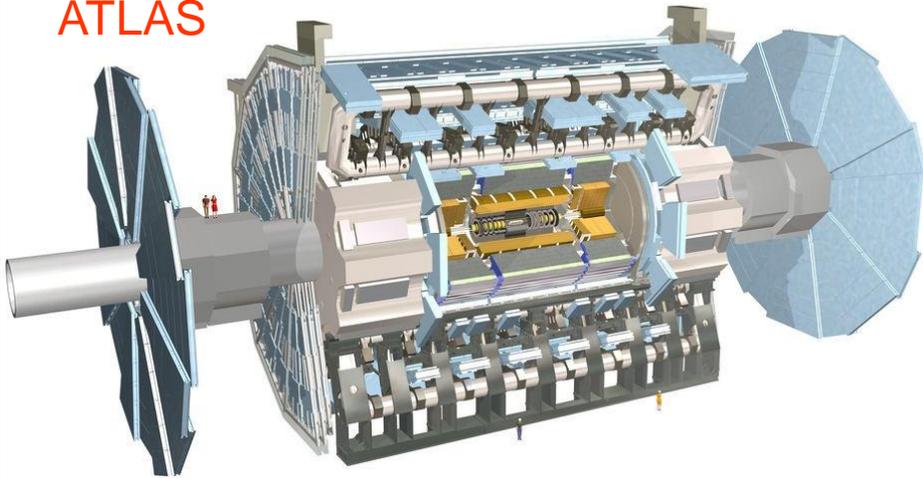
# The Emptiest Space in the Solar System

A long, brightly lit tunnel filled with large, cylindrical metal pipes, likely part of a particle accelerator. A person wearing a VR headset is visible in the foreground, looking at the equipment. The tunnel is filled with various pipes, cables, and structural elements, creating a complex industrial environment.

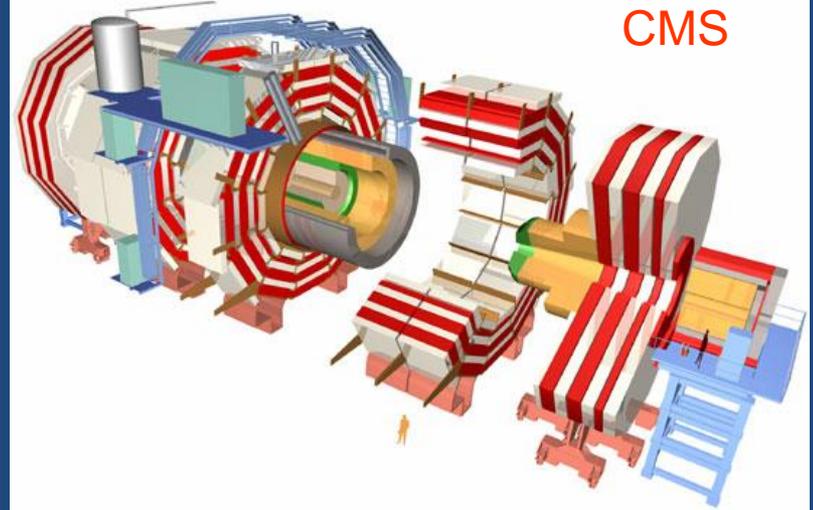
**Vacuum similar to interplanetary space:  
the pressure in the beam-pipes is ten times lower  
than on the Moon**

# The Four LHC Detectors

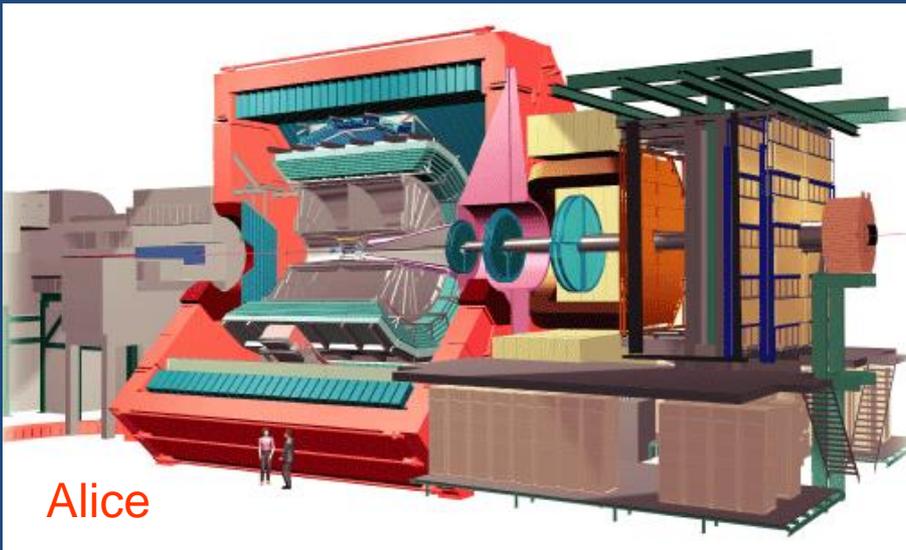
ATLAS



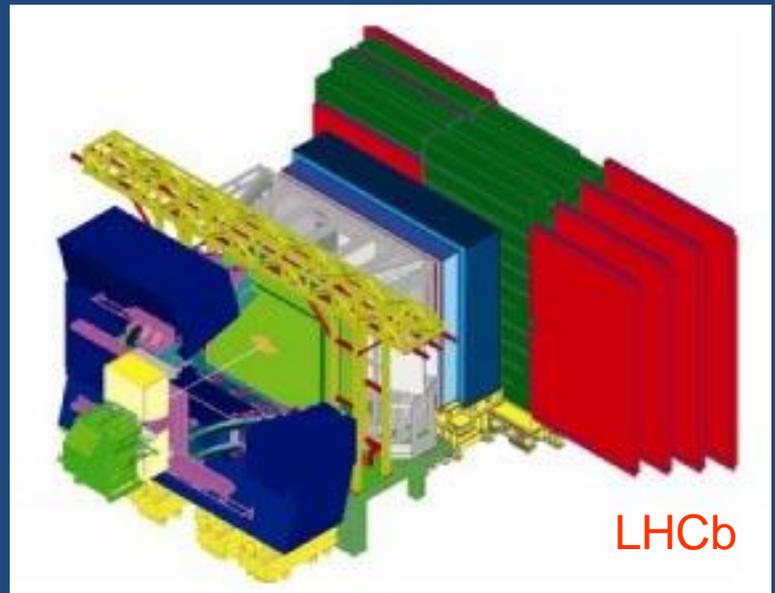
CMS

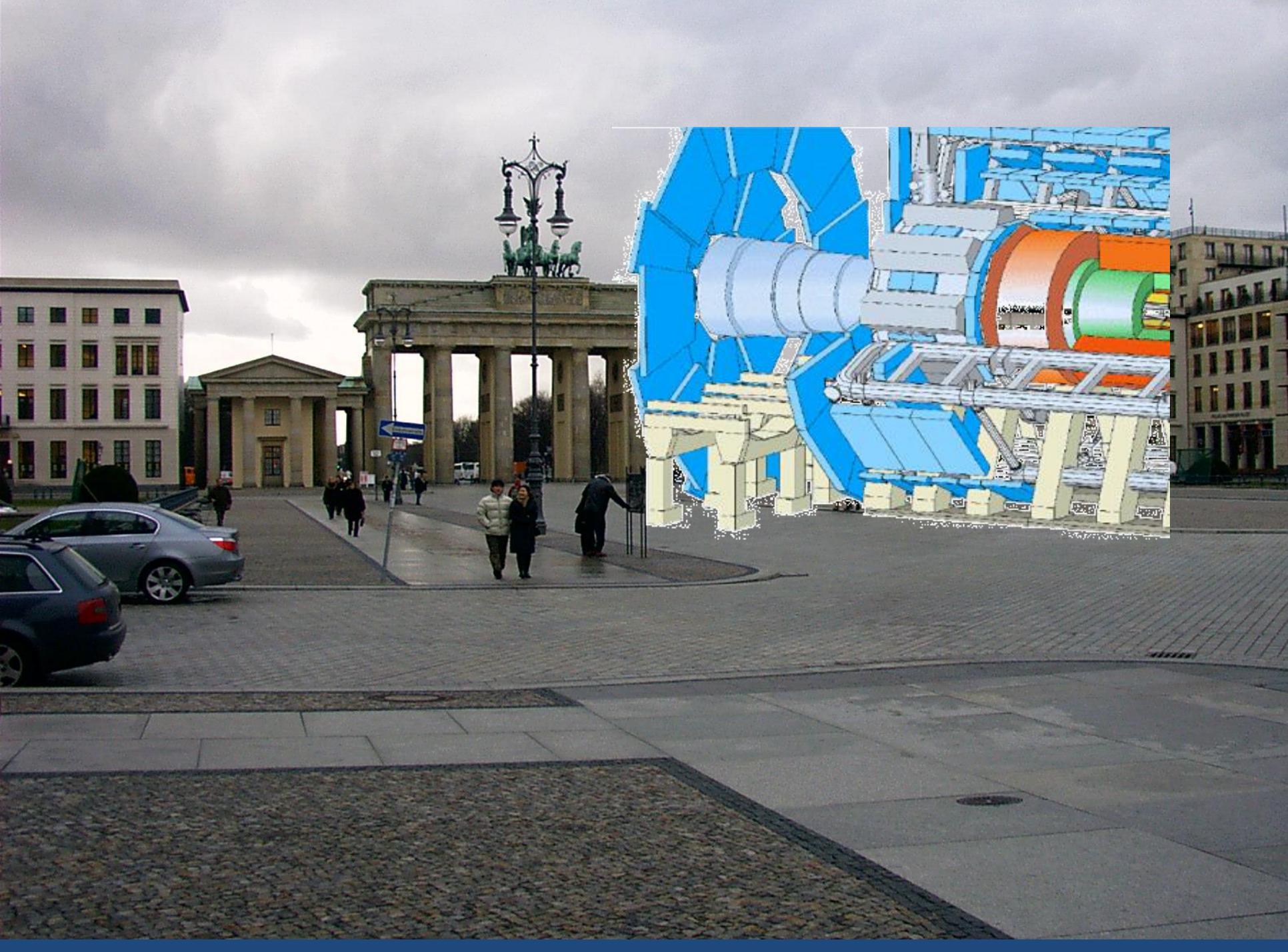


Alice

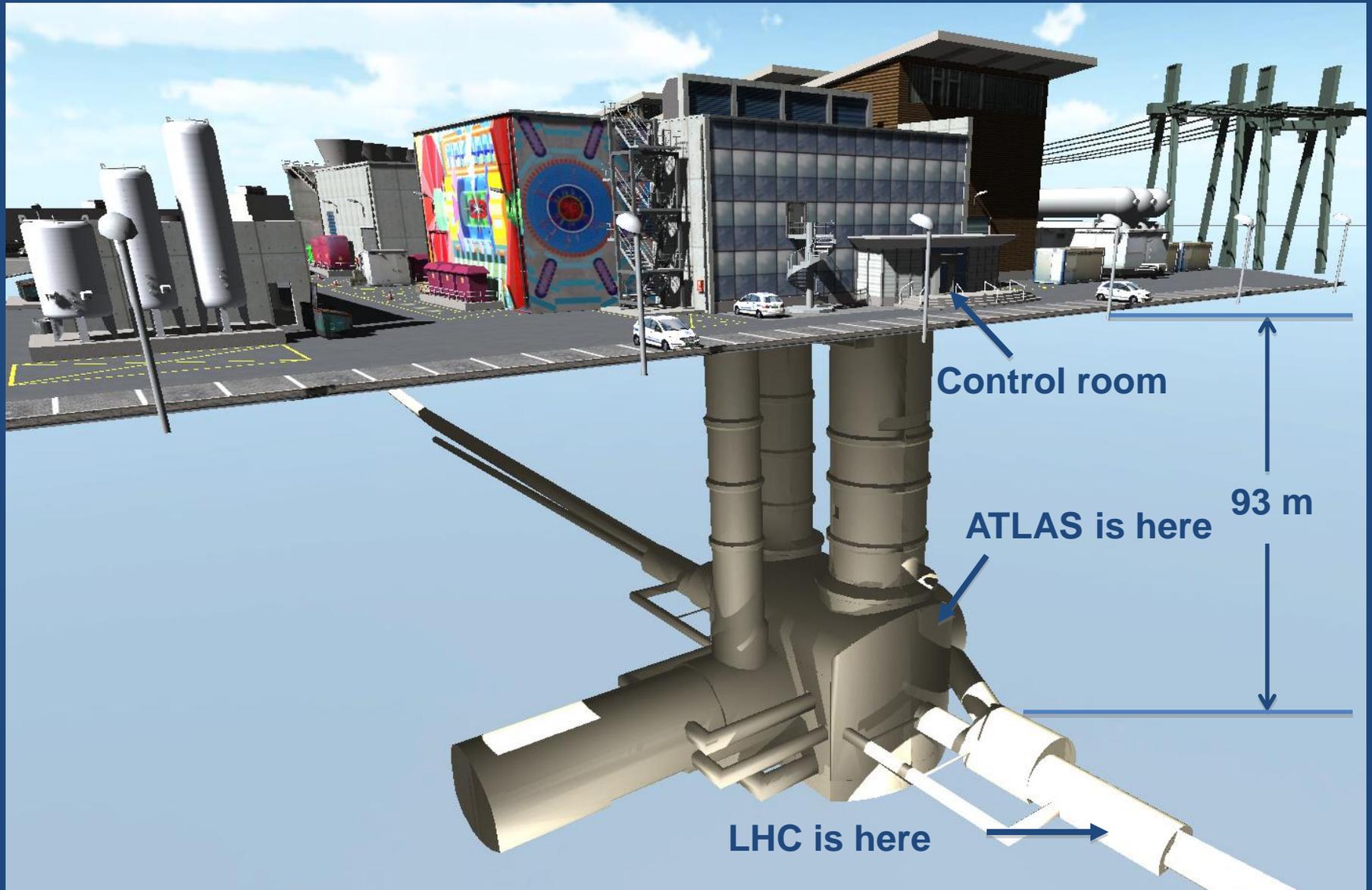


LHCb



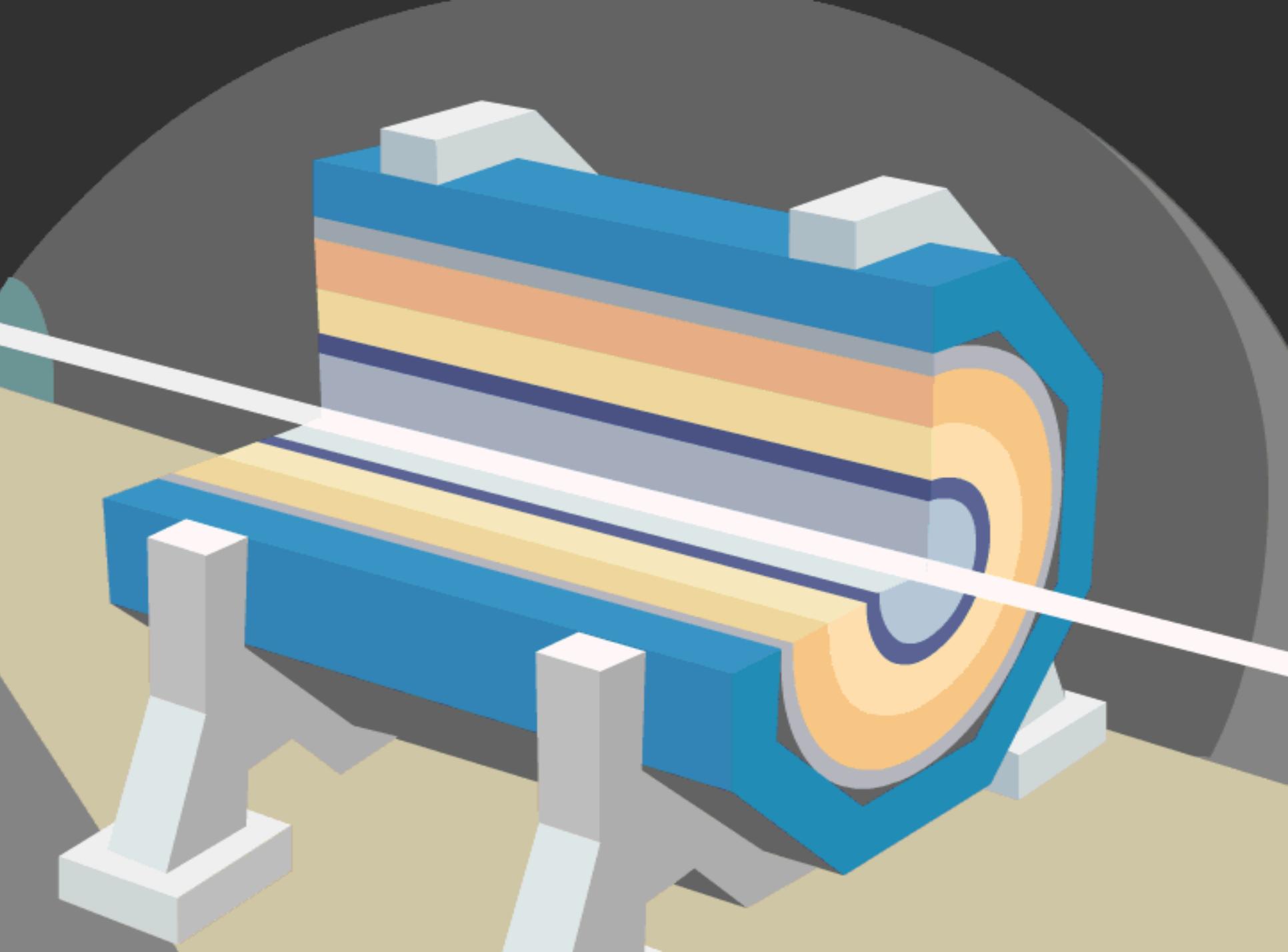


# Site of the ATLAS experiment

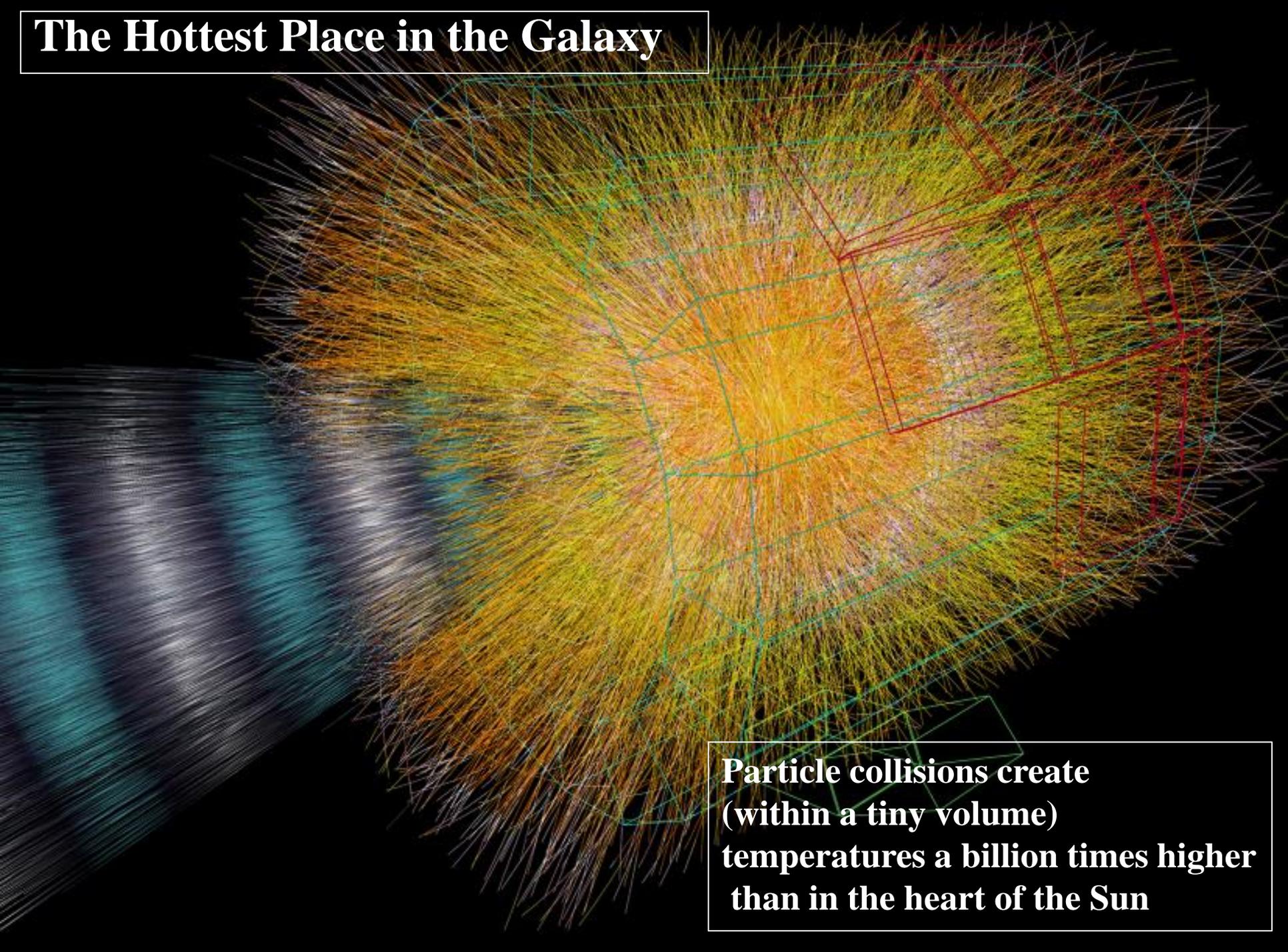


# The CMS Detector before closing





# The Hottest Place in the Galaxy

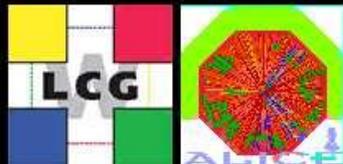


**Particle collisions create  
(within a tiny volume)  
temperatures a billion times higher  
than in the heart of the Sun**

# LCG-LHC Computing GRID

Oct 6, 2010 7:20:00 am

Running jobs: 100767.0  
Transfer rate: 5.74 GiB/sec



dashboard

© 2010 Europa Technologies  
US Dept of State Geographer

© 2010 Google  
© 2010 Tele Atlas

22°34'45.42" N 15°53'35.50" E elev=2326 ft

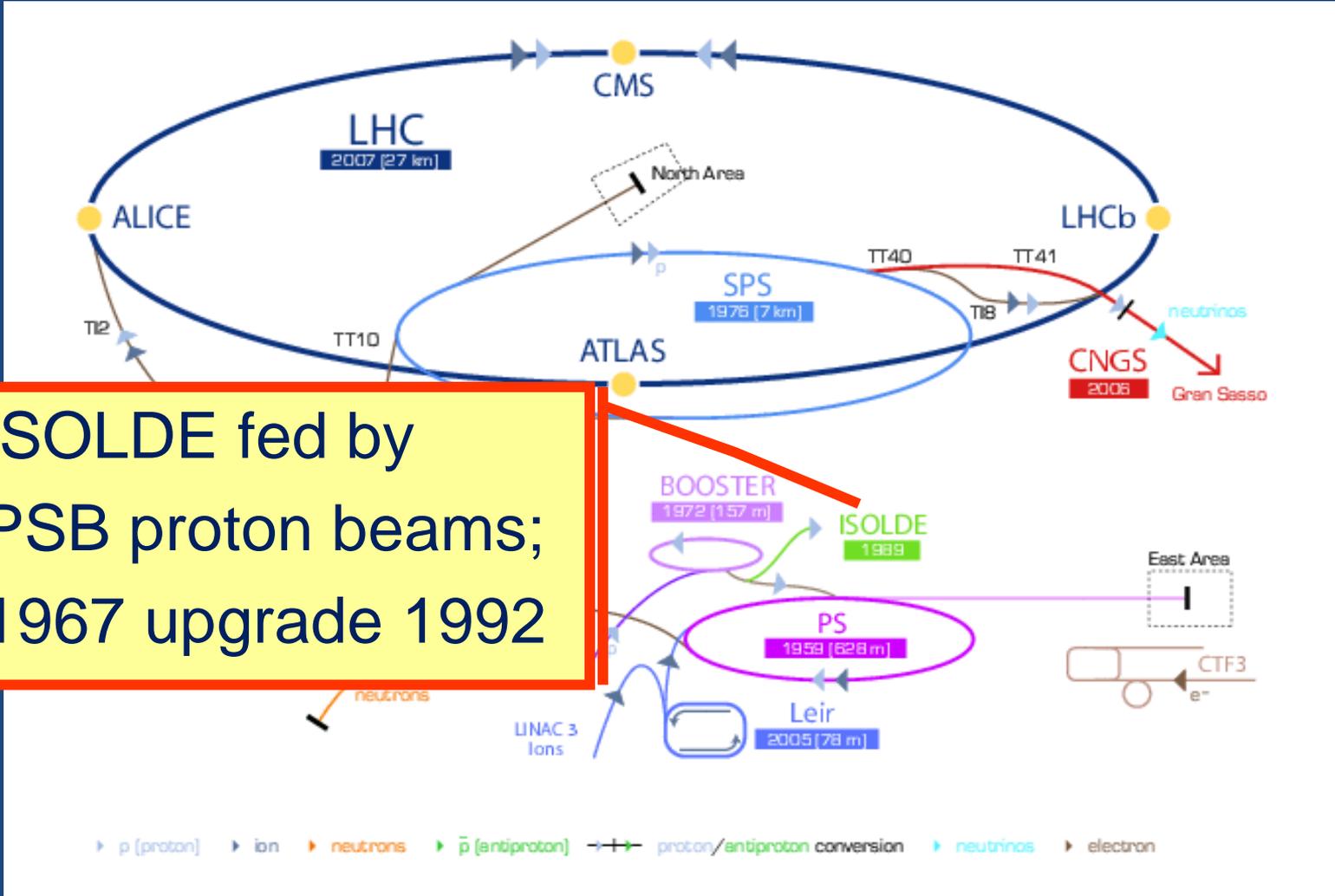
©2010 Google

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# CERN accelerator complex, working not only for LHC

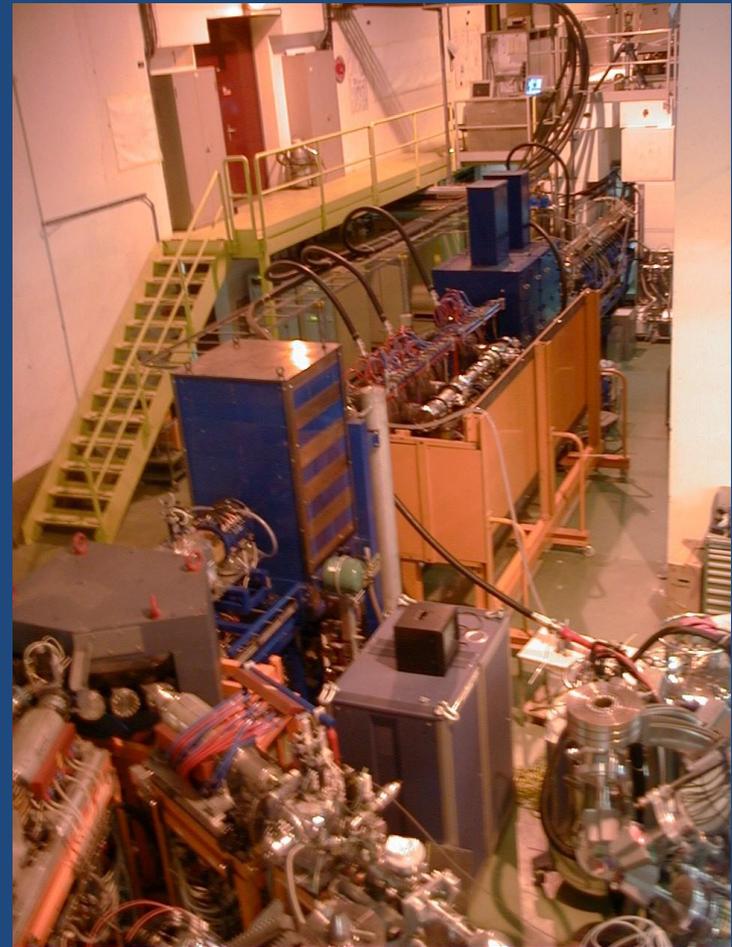
ISOLDE fed by  
PSB proton beams;  
1967 upgrade 1992



# 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.

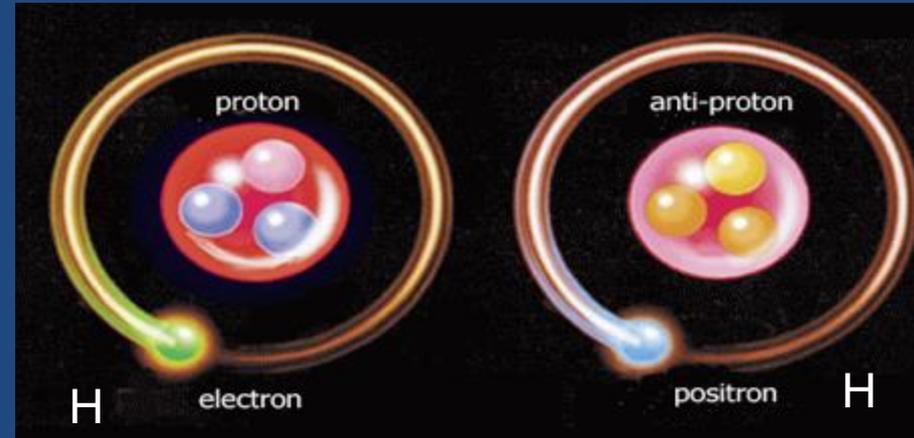


# Antimatter Physics

## Matter-Antimatter comparison

*Very fundamental in our theory of physics*

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



**ASACUSA**  
**ATRAP**  
**ALPHA**

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

**AEGIS**

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

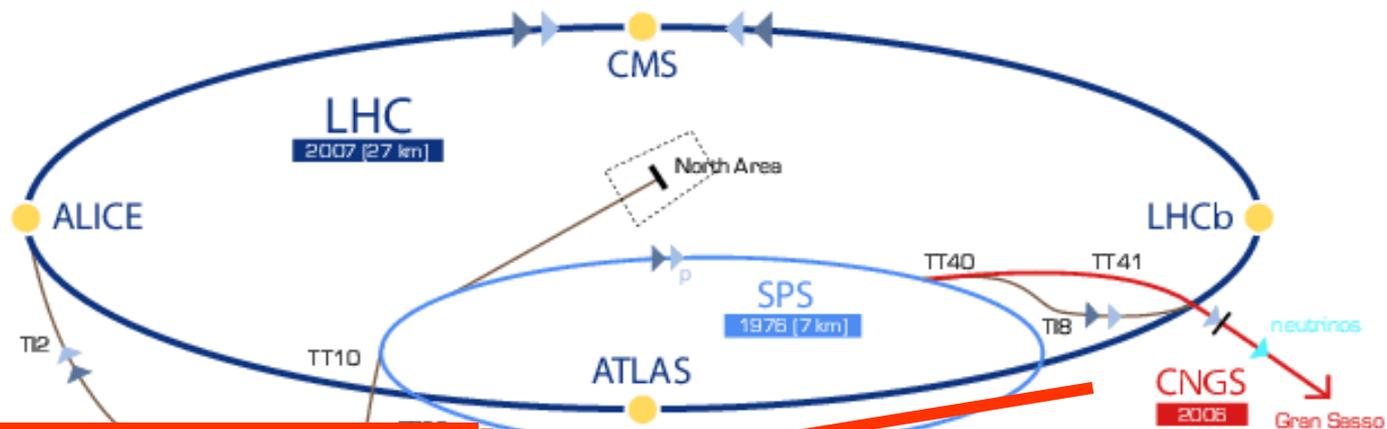


**ACE**

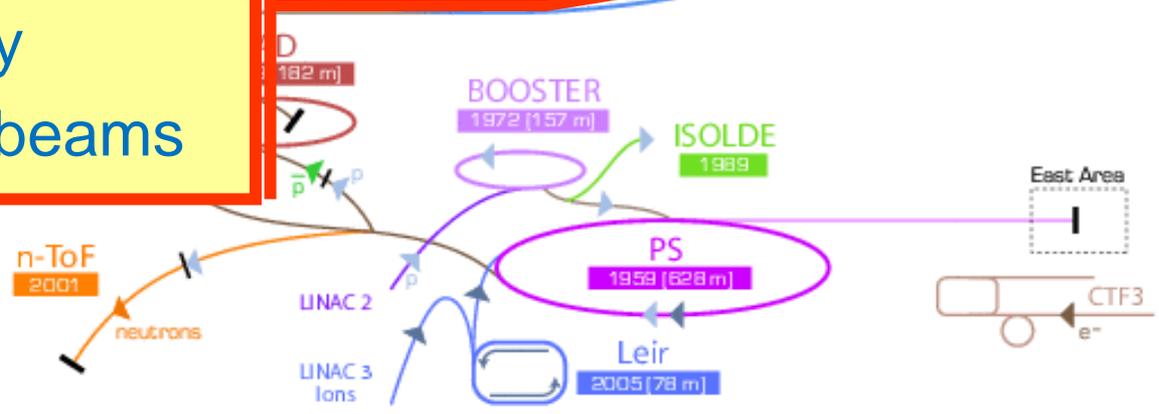
Biological effect of  $\bar{p}$   
Possible use for cancer therapy



# CERN accelerator complex, working not only for LHC !



CNGS fed by SPS proton beams

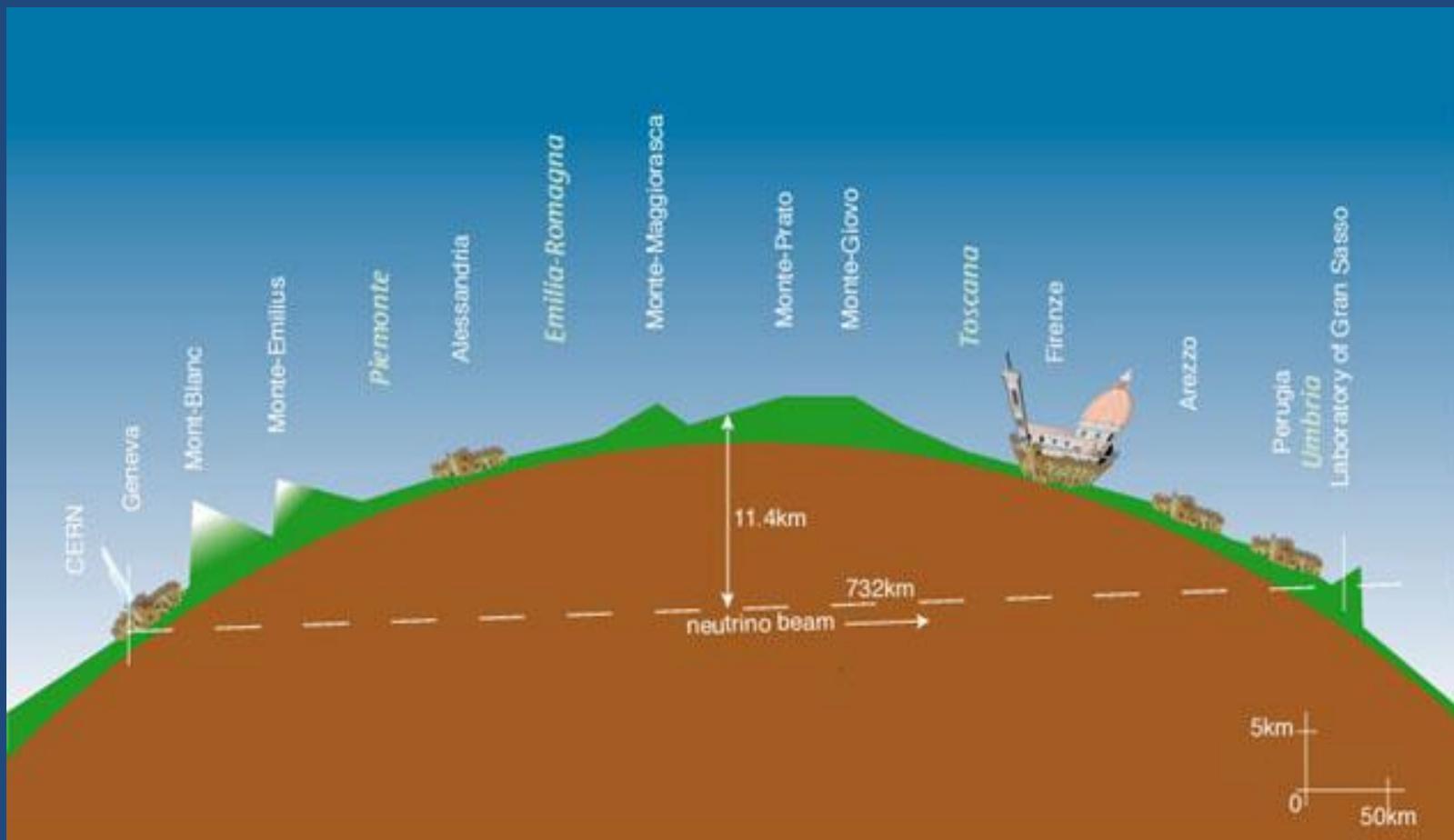


▶ p [proton] ▶ ion ▶ neutrons ▶  $\bar{p}$  [antiproton] ▶  $\leftrightarrow$  proton/antiproton conversion ▶ neutrinos ▶ electron

# 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 a beam, clouds created  
in a large climatic chamber)



# Nobel prize 1984: CERN



*"for their decisive contributions to the large project, which led to the discovery of the field particles  $W$  and  $Z$ , communicators of weak interaction"*

# Nobel prize 1988: CERN



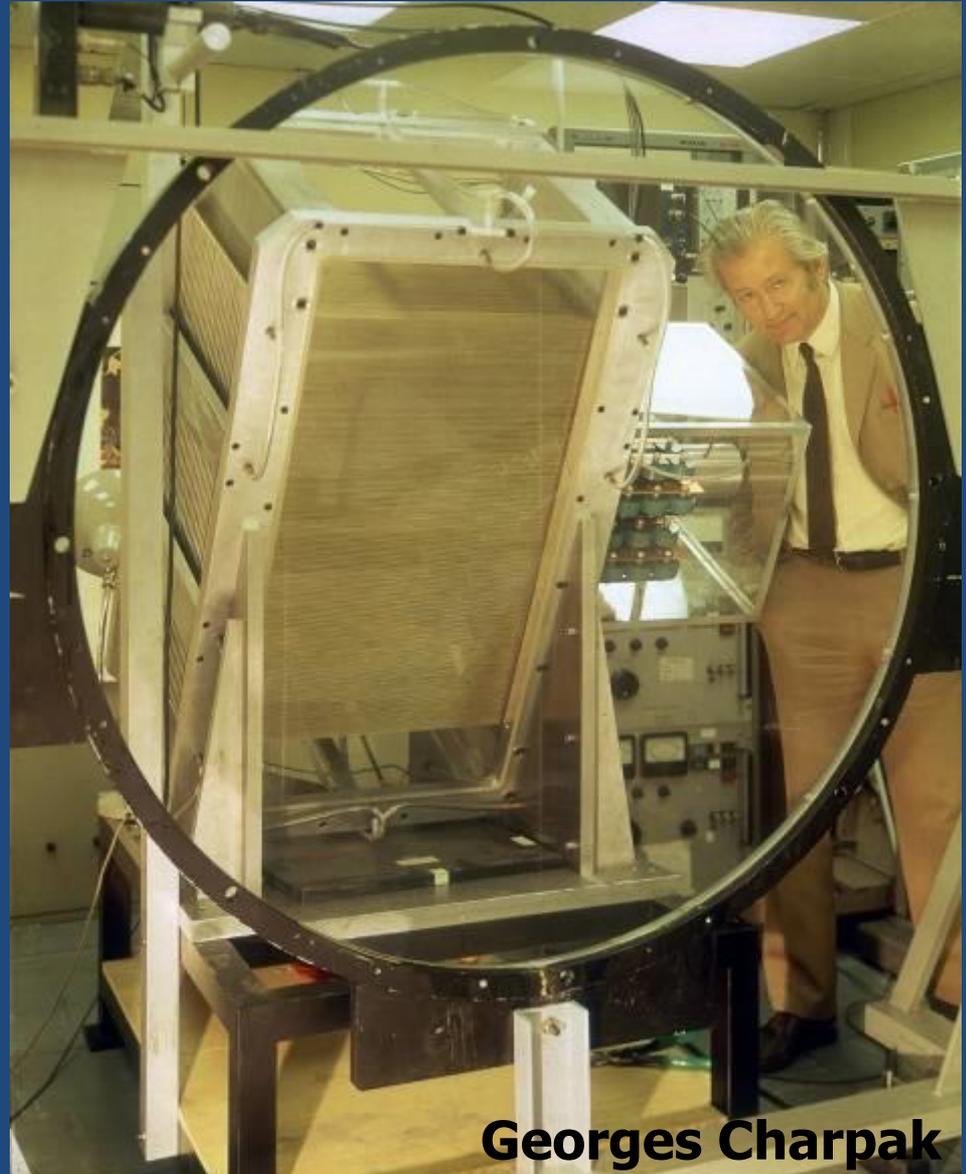
*"for the neutrino beam method and the demonstration of the doublet structure of the leptons through the discovery of the muon neutrino"*

# Nobel prize 1992: CERN

We (physicists) cannot just go to a shop and buy our detectors.

So we invent them !

*"for his invention and development of particle detectors, in particular the multiwire proportional chamber"*



**Georges Charpak**

# CERN Technologies - Innovation

Accelerating  
particle  
beams

Medical imaging



Charged hadron beam that  
loses energy in matter

Detecting  
particles

Grid computing  
for big data  
management and  
analysis



Drugs hidden inside the  
gas tank

# World Wide Web, GRID, Computing...

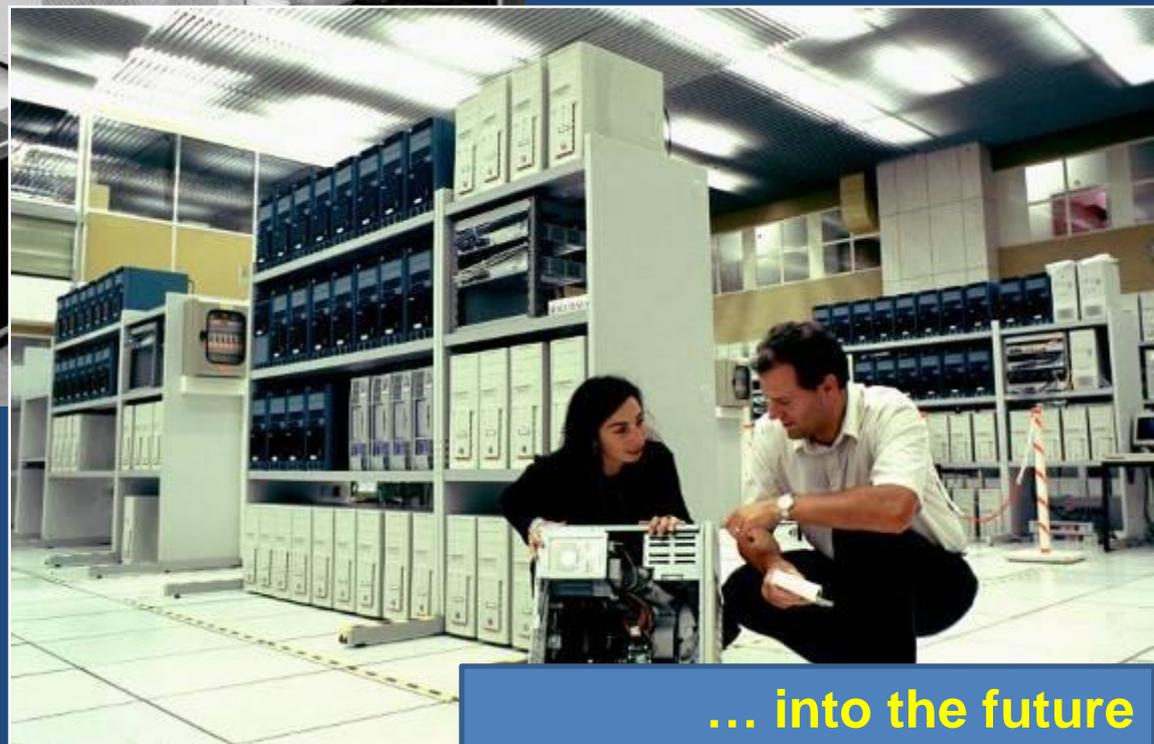


From the past...

[www.cern.ch](http://www.cern.ch)



Tim Berners-Lee  
father of WWW



... into the future

# CERN Education Activities

## Scientists at CERN

Academic Training Programme

## For young Researchers:

School of High Energy Physics  
School of Computing  
Accelerator School

## CERN Personnel

Training Programmes:  
Language, Management,  
Technical



## Physics Students

Summer Students  
Programme



## CERN Teacher Schools

International and National  
Programmes

# Ukrainian participation in the CERN Educational Programmes

**2011** Signature of Joint Declaration concerning participation by Ukrainian teachers and students in educational programmes at CERN by the Minor Academy of Science of Ukraine (MASU) and CERN



**1st national Ukrainian Teachers Programme at CERN in November 2011**

# Ukrainian participation in the CERN Educational Programmes

Since that time:

MASU has been organizing and financing the Ukrainian Teacher Programme at CERN (UkrTP);

UkrTP **2013** will be the third and will start on 6 October  
(20 teachers from different regions of Ukraine)

57 teachers participated in two previous programmes

## Ukrainian participation in the CERN Educational Programmes

4 video conferences were organized with Ukraine:

350 university students and school students participated (one with participation of the Minister of Education and Science)

Two groups of Ukrainian school students (14 in 2012 and 12 in 2013) of 15-16 years old came to CERN for a two-day visit

# Ukrainian participation in the CERN Educational Programmes

High School Teachers Conference organized by MASU, CERN, CMS and JINR 29<sup>th</sup> of May 2012 in Alushta, Ukraine.



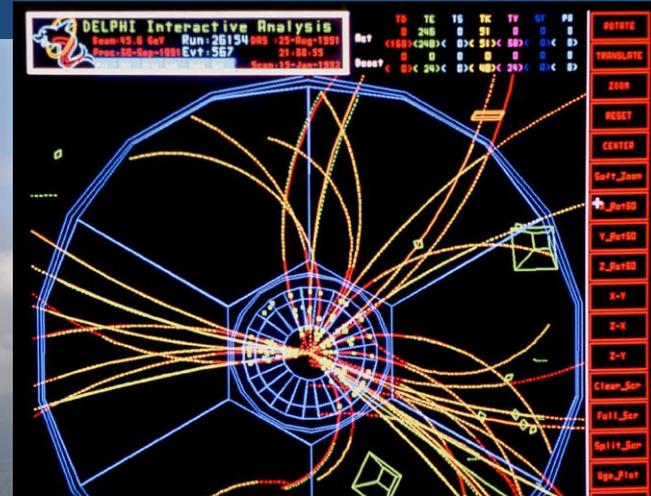
The conference was a great success, and it was attended by approximately 170 participants

# CERN Visit Programme

## Multinational and multilingual

- **Visits**
  - more than 80 000 visitors per year
  - 50 % from schools and universities
- **Video conferences with  
Schools and Universities**
- **Conferences**
- **Science fairs**

International Collaboration



Fundamental Research

Technology Transfer

Education Training  
the scientists of  
tomorrow



Спасибо за внимание

