

CERN

European Organization for Nuclear Research  
Organisation Européenne pour la Recherche Nucléaire

# CERN – Research, Innovation and Education

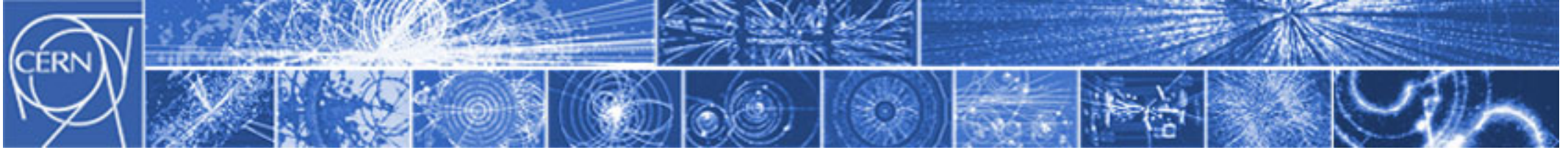
Mick Storr

Head Teacher Programmes and Visits Service

CERN

Geneva, Switzerland





## 30<sup>th</sup> 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



# CERN was founded 1954: 12 European States Today: 20 Member States



~ 2300 staff  
~ 790 other paid personnel  
> 10000 users  
Budget (2011) ~1000 MCHF

**20 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

**Candidate for Accession:** Romania

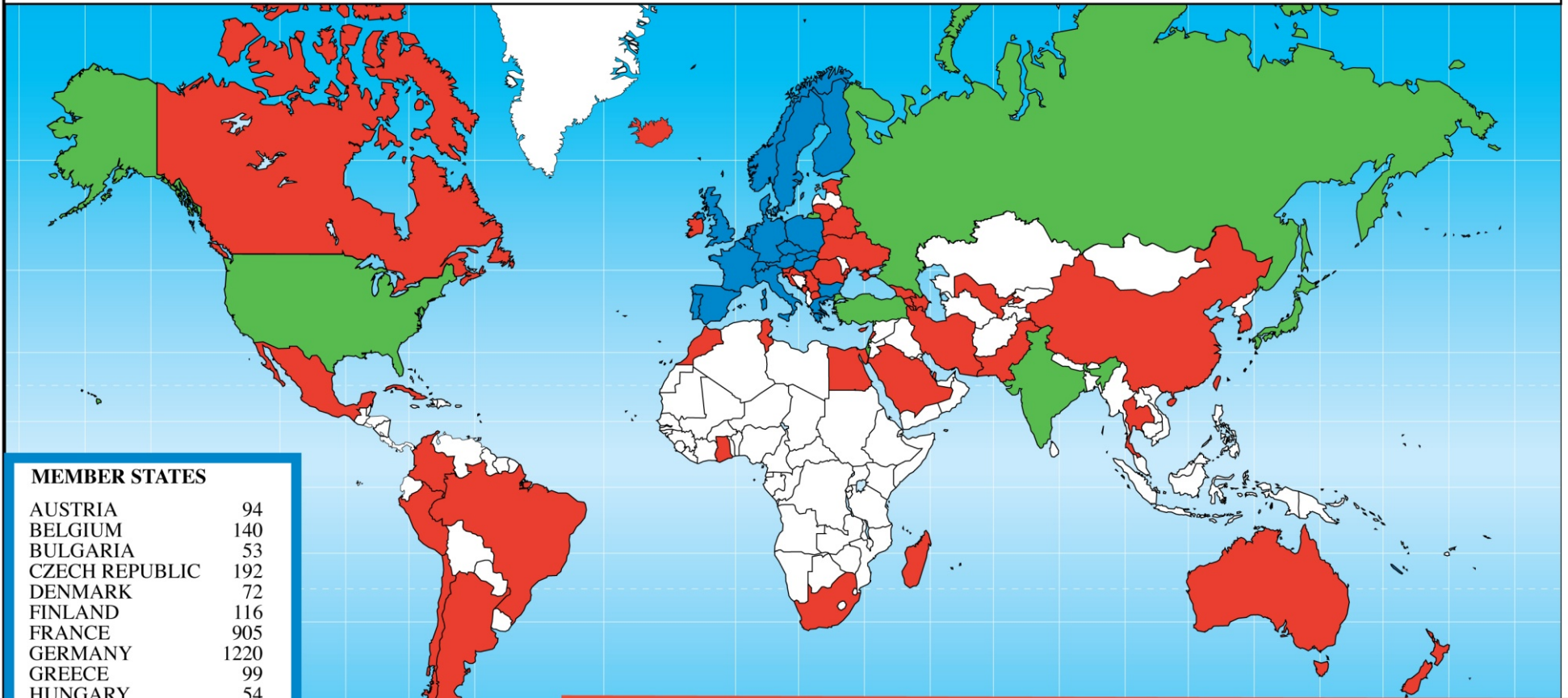
**Associate Member States :** Israel, Serbia

**Observers to Council:** India, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO



# Science is ever more global

## Distribution of All CERN Users by Nation of Institute on 27 June 2011



### MEMBER STATES

AUSTRIA	94
BELGIUM	140
BULGARIA	53
CZECH REPUBLIC	192
DENMARK	72
FINLAND	116
FRANCE	905
GERMANY	1220
GREECE	99
HUNGARY	54
ITALY	1406
NETHERLANDS	180
NORWAY	93
POLAND	205
PORTUGAL	141
SLOVAKIA	63
SPAIN	339
SWEDEN	79
SWITZERLAND	359
UNITED KINGDOM	732

### OBSERVER STATES

INDIA	109
ISRAEL	60
JAPAN	190
RUSSIA	822
TURKEY	79
USA	1786

### OTHERS

ARGENTINA	12	CUBA	4	LITHUANIA	11	SERBIA	24
ARMENIA	12	CYPRUS	6	MADAGASCAR	1	SINGAPORE	1
AUSTRALIA	22	EGYPT	6	MALTA	1	SLOVENIA	31
AZERBAIJAN	1	ESTONIA	18	MEXICO	39	SOUTH AFRICA	15
BELARUS	19	GEORGIA	10	MONTENEGRO	1	THAILAND	1
BRAZIL	79	GHANA	1	MOROCCO	7	F.Y.R.O.M.	3
CANADA	160	HONG KONG	1	NEW ZEALAND	9	TUNISIA	1
CHILE	3	ICELAND	3	PAKISTAN	19	UKRAINE	19
CHINA	87	IRAN	15	PERU	2	UZBEKISTAN	1
CHINA (TAIPEI)	53	IRELAND	13	QATAR	1		
COLOMBIA	13	KOREA	85	ROMANIA	66		
CROATIA	15	LEBANON	1	SAUDI ARABIA	2		

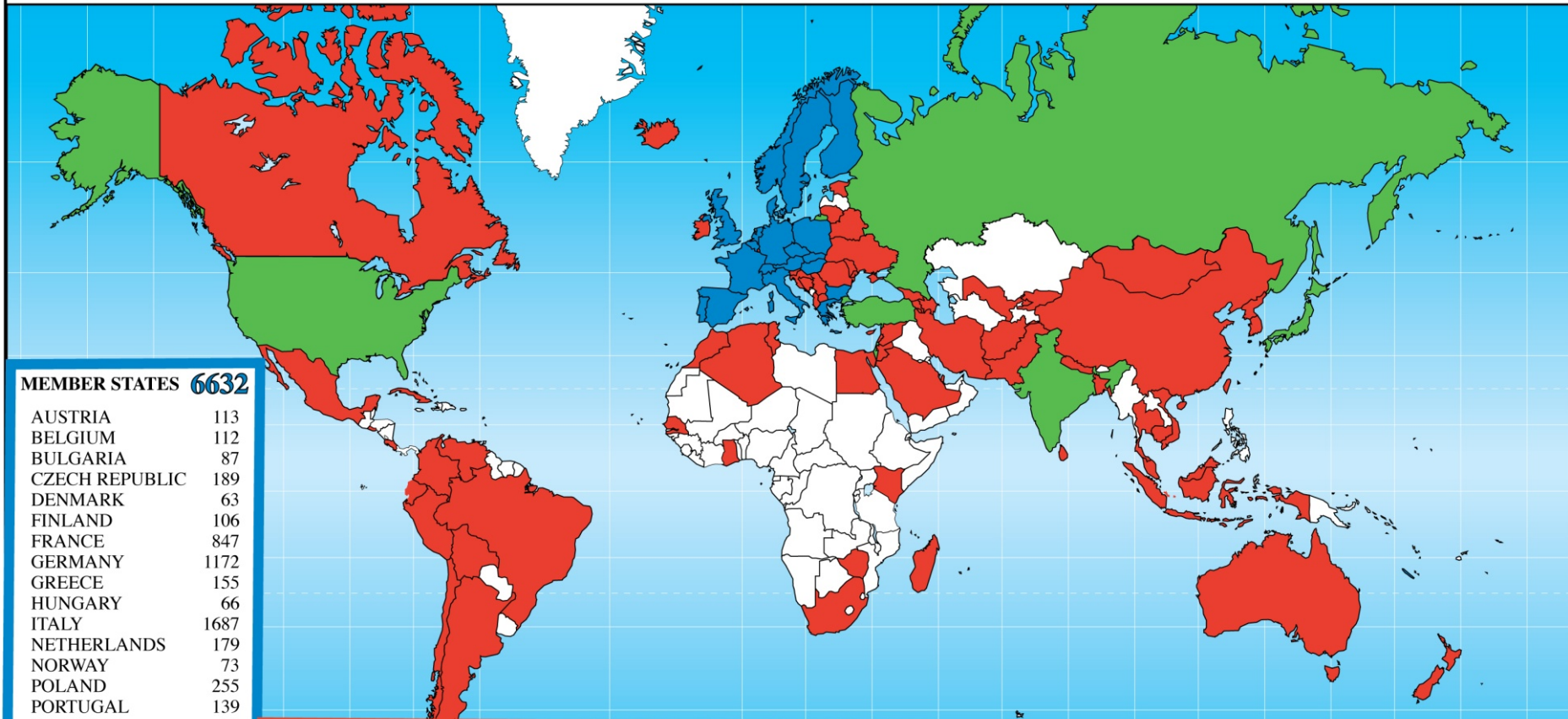
6542

3046

894

# Science is ever more global

## Distribution of All CERN Users by Nationality on 27 June 2011



### MEMBER STATES 6632

AUSTRIA	113
BELGIUM	112
BULGARIA	87
CZECH REPUBLIC	189
DENMARK	63
FINLAND	106
FRANCE	847
GERMANY	1172
GREECE	155
HUNGARY	66
ITALY	1687
NETHERLANDS	179
NORWAY	73
POLAND	255
PORTUGAL	139
SLOVAKIA	94
SPAIN	358
SWEDEN	79
SWITZERLAND	216
UNITED KINGDOM	642

### OBSERVER STATES 2537

INDIA	192
ISRAEL	61
JAPAN	223
RUSSIA	955
TURKEY	106
USA	1000

### OTHERS 1364

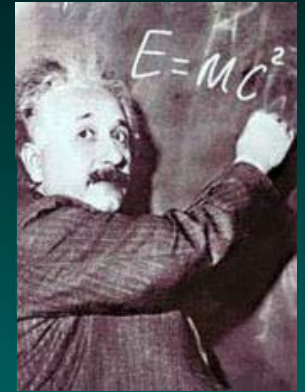
AFGHANISTAN	1	BRAZIL	83	EL SALVADOR	1	KOREA REP.	103	NEW ZEALAND	9	SRI LANKA	5
ALBANIA	3	CAMBODIA	1	ESTONIA	15	KYRGYZSTAN	1	PAKISTAN	39	SYRIA	2
ALGERIA	12	CANADA	143	GEORGIA	32	LEBANON	10	PALESTINE (O.T.)	1	THAILAND	3
ARGENTINA	13	CHILE	3	GHANA	1	LITHUANIA	17	PERU	4	F.Y.R.O.M.	2
ARMENIA	22	CHINA	232	GIBRALTAR	1	LUXEMBOURG	4	QATAR	1	TUNISIA	7
AUSTRALIA	20	CHINA (TAIPEI)	42	HONG KONG	1	MADAGASCAR	4	ROMANIA	106	UKRAINE	40
AZERBAIJAN	6	COLOMBIA	31	ICELAND	3	MALAYSIA	4	SAN MARINO	1	UZBEKISTAN	3
BANGLADESH	2	COSTA RICA	2	INDONESIA	2	MALTA	2	SAUDI ARABIA	3	VENEZUELA	11
BELARUS	36	CROATIA	22	IRAN	23	MEXICO	54	SENEGAL	1	VIET NAM	9
BOLIVIA	2	CUBA	5	IRELAND	25	MOLDOVA	1	SERBIA	38	ZIMBABWE	1
BOSNIA AND HERZEGOVINA	1	CYPRUS	14	JORDAN	1	MONGOLIA	1	SINGAPORE	1		
		ECUADOR	2	KENYA	1	MOROCCO	15	SLOVENIA	32		
		EGYPT	9	KOREA, D.P.R.	3	NEPAL	2	SOUTH AFRICA	11		

# 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?



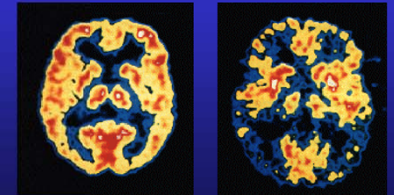
- **Develop** new technologies for accelerators and detectors

Information technology - the World Wide Web  
Medicine - diagnosis and treatment

CERN



Brain Metabolism in Alzheimer's Disease: PET Scan



- **Train** scientists of tomorrow

uniting people

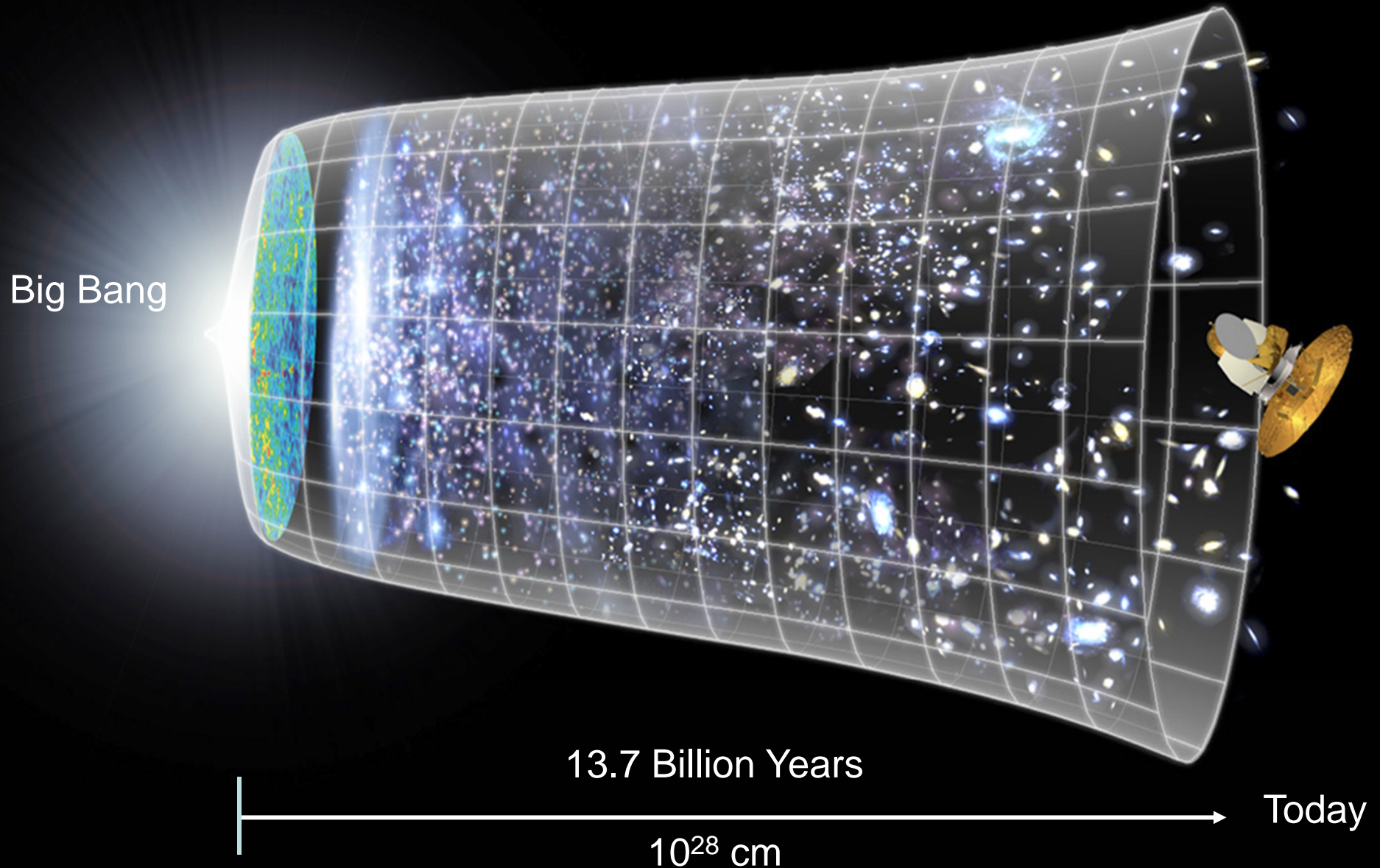


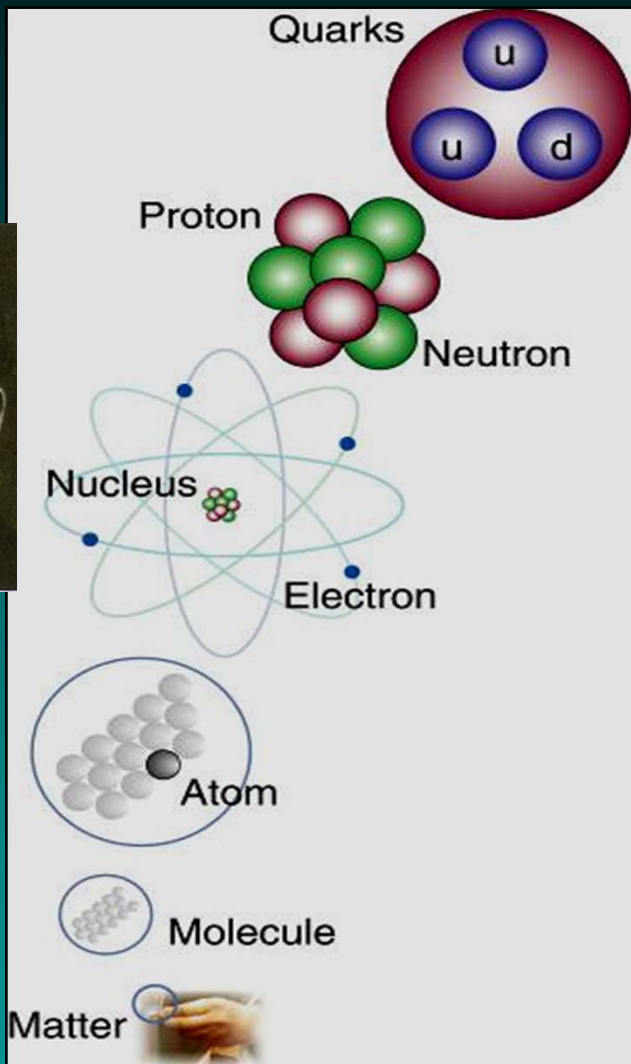
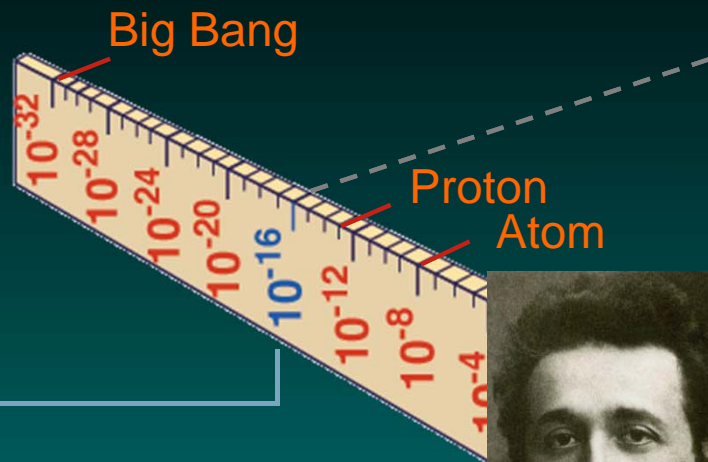
- **Unite** people from different countries and cultures

Research



# Evolution of the Universe





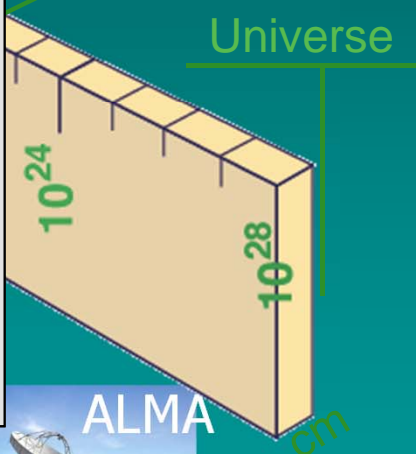
LHC

Super-Microscope

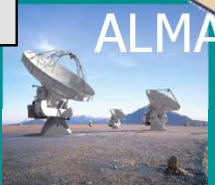


Study physics laws of first moments after Big Bang  
 increasing Symbiosis between Particle Physics,  
 Astrophysics and Cosmology

Radius of Galaxies



AMS



ALMA



VLT





CERN

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



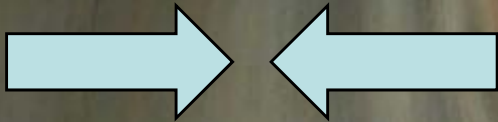
**The aim of particle physics, CERN & the LHC:  
What is the Universe made of?**



# The Large Hadron Collider (LHC)

Proton- Proton Collider

4 TeV + 4 TeV



1,000,000,000 collisions/second

Total energy over 8,000 proton masses

Primary targets:

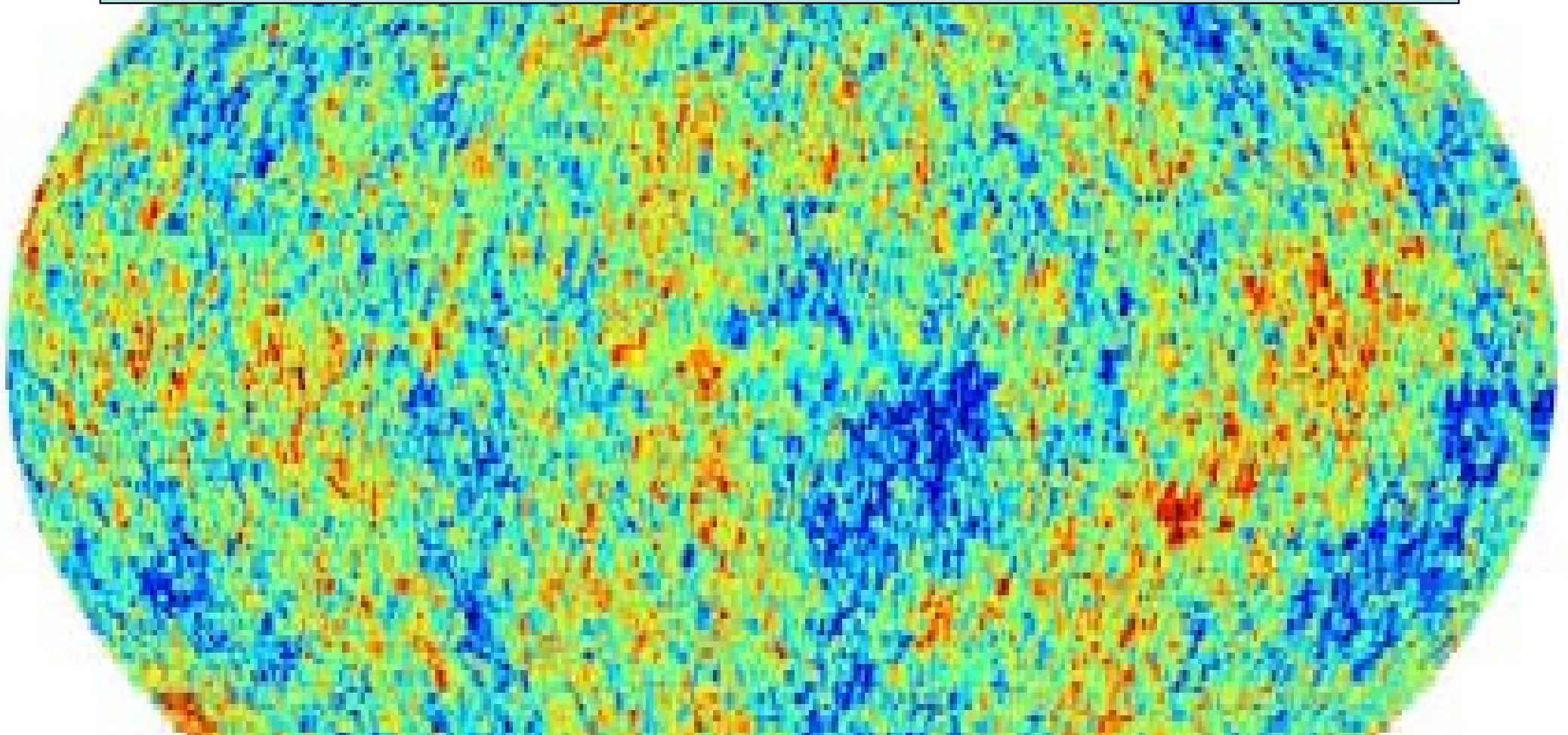
- Origin of mass
- Nature of Dark Matter
- Primordial Plasma
- Matter vs Antimatter

# 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

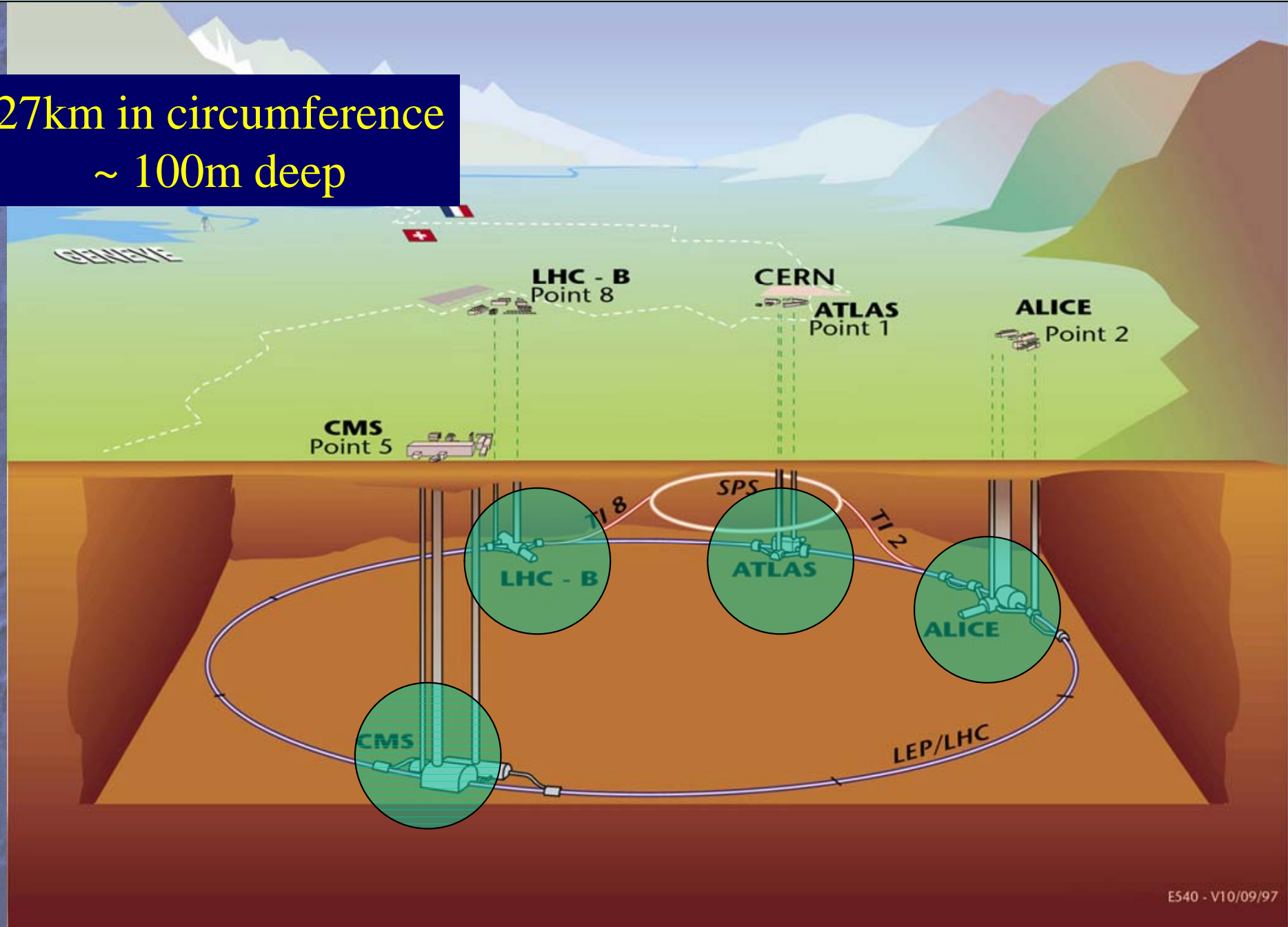


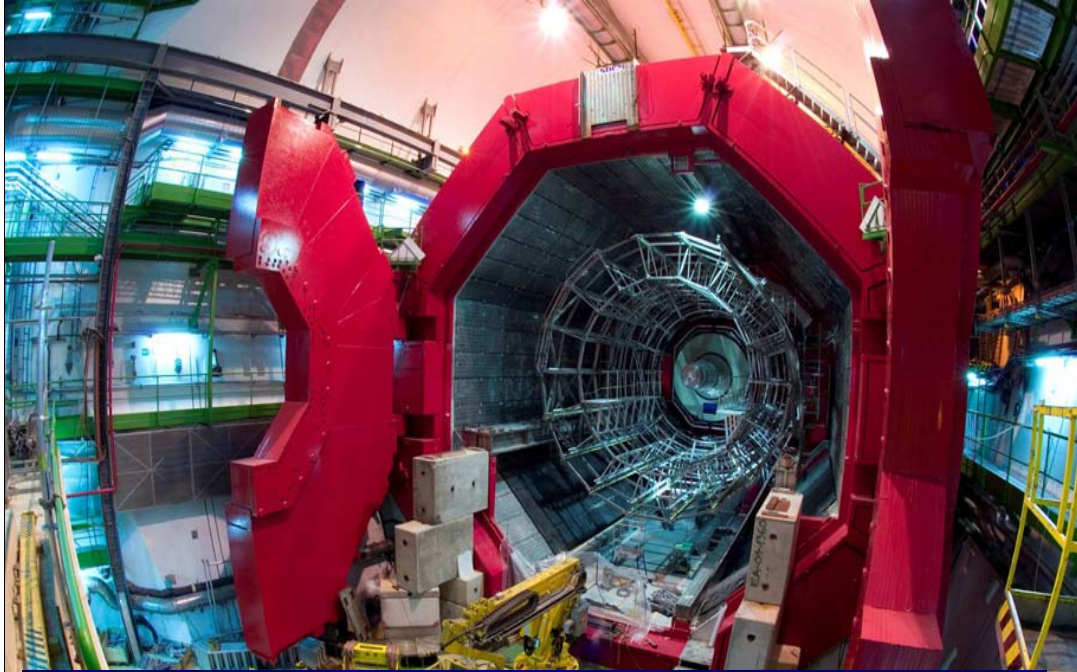
**LHC 1.9 degrees above absolute zero = - 271 C**

**Outer space 2.7 degrees above zero = - 270 C**

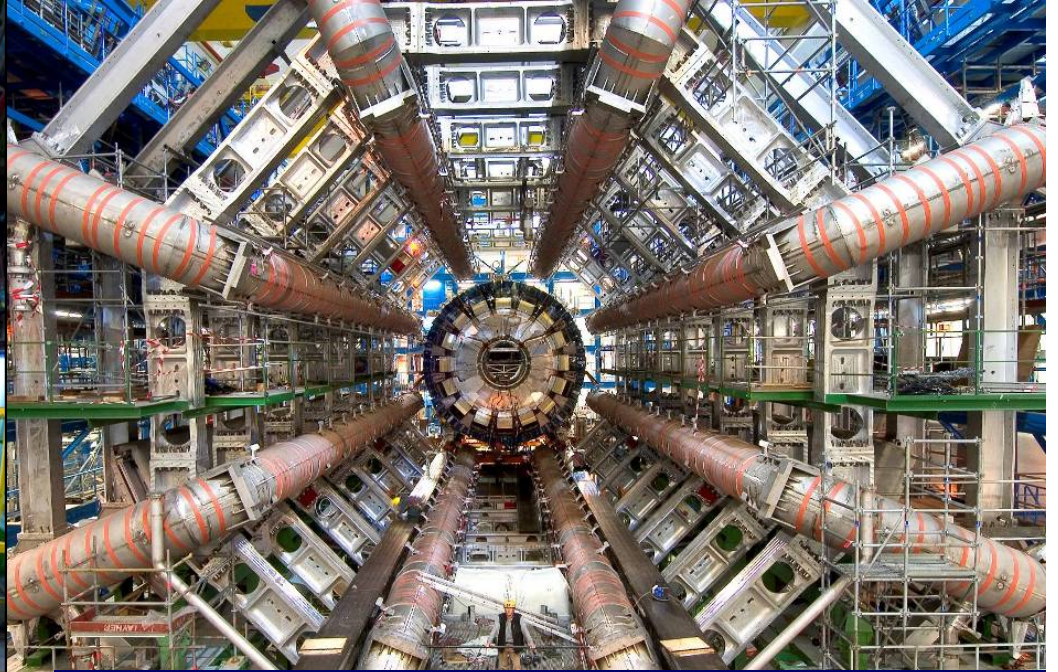
# General View of LHC & its Experiments

27km in circumference  
~ 100m deep

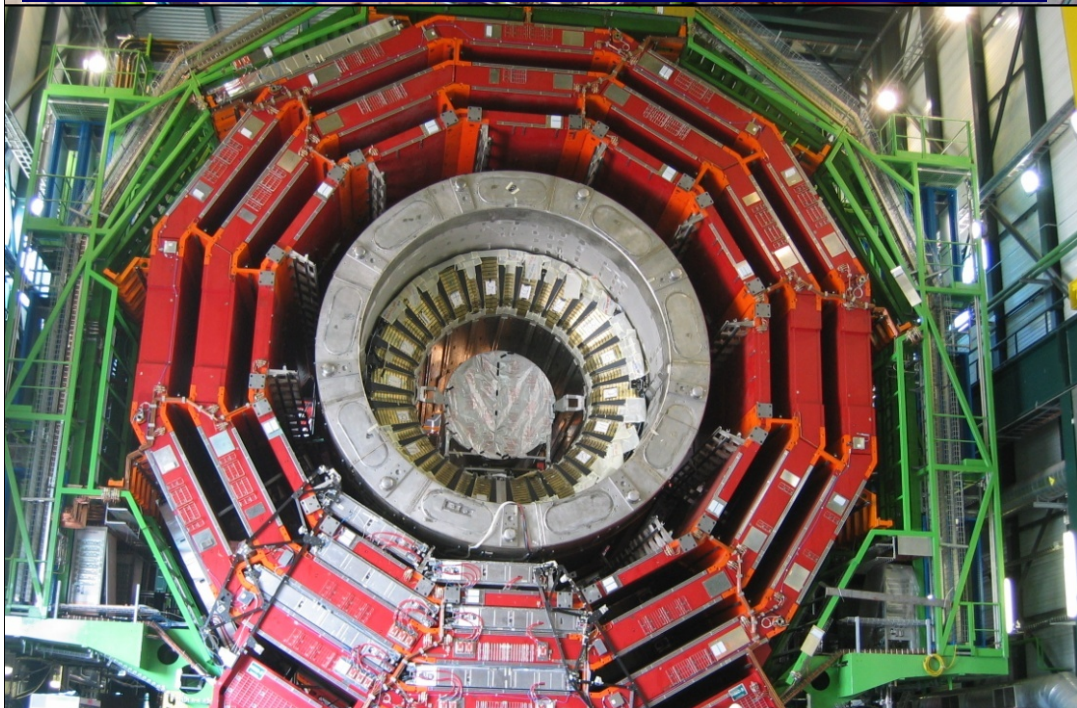




**ALICE: Primordial cosmic plasma**



**ATLAS: Higgs and supersymmetry**



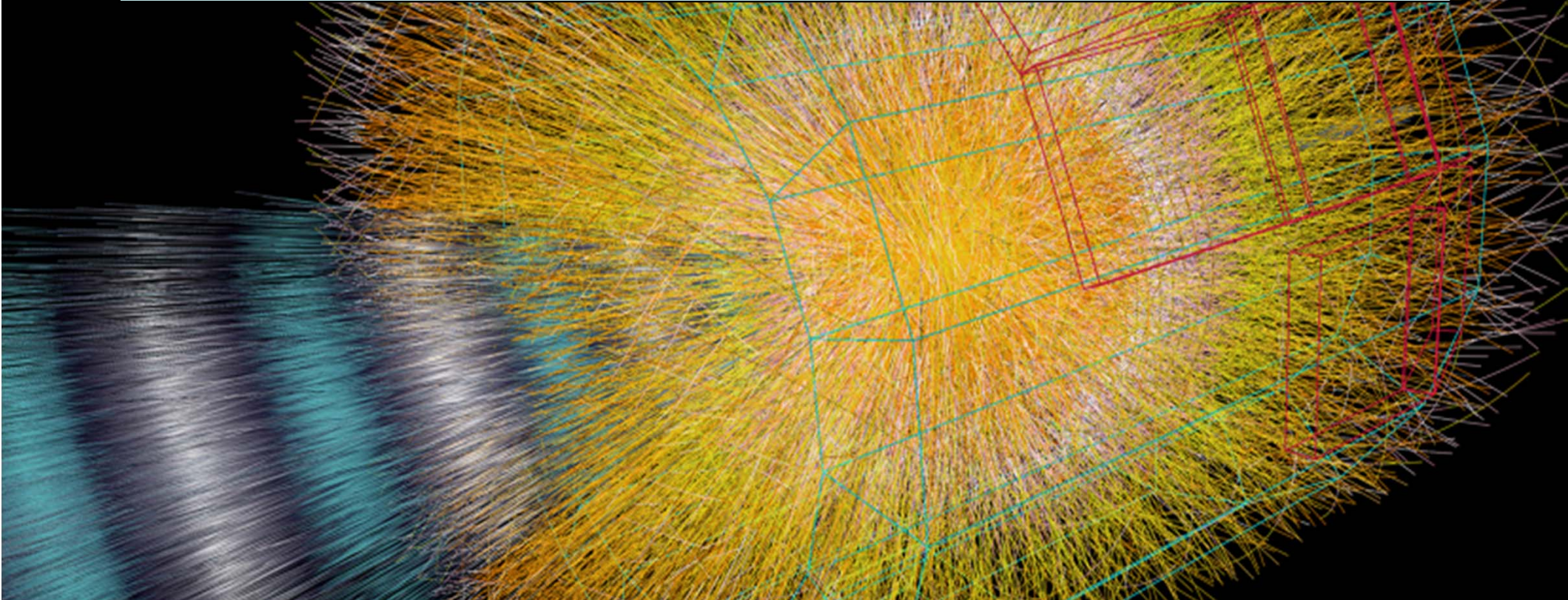
**CMS: Higgs and supersymmetry**



**LHCb: Matter-antimatter difference**

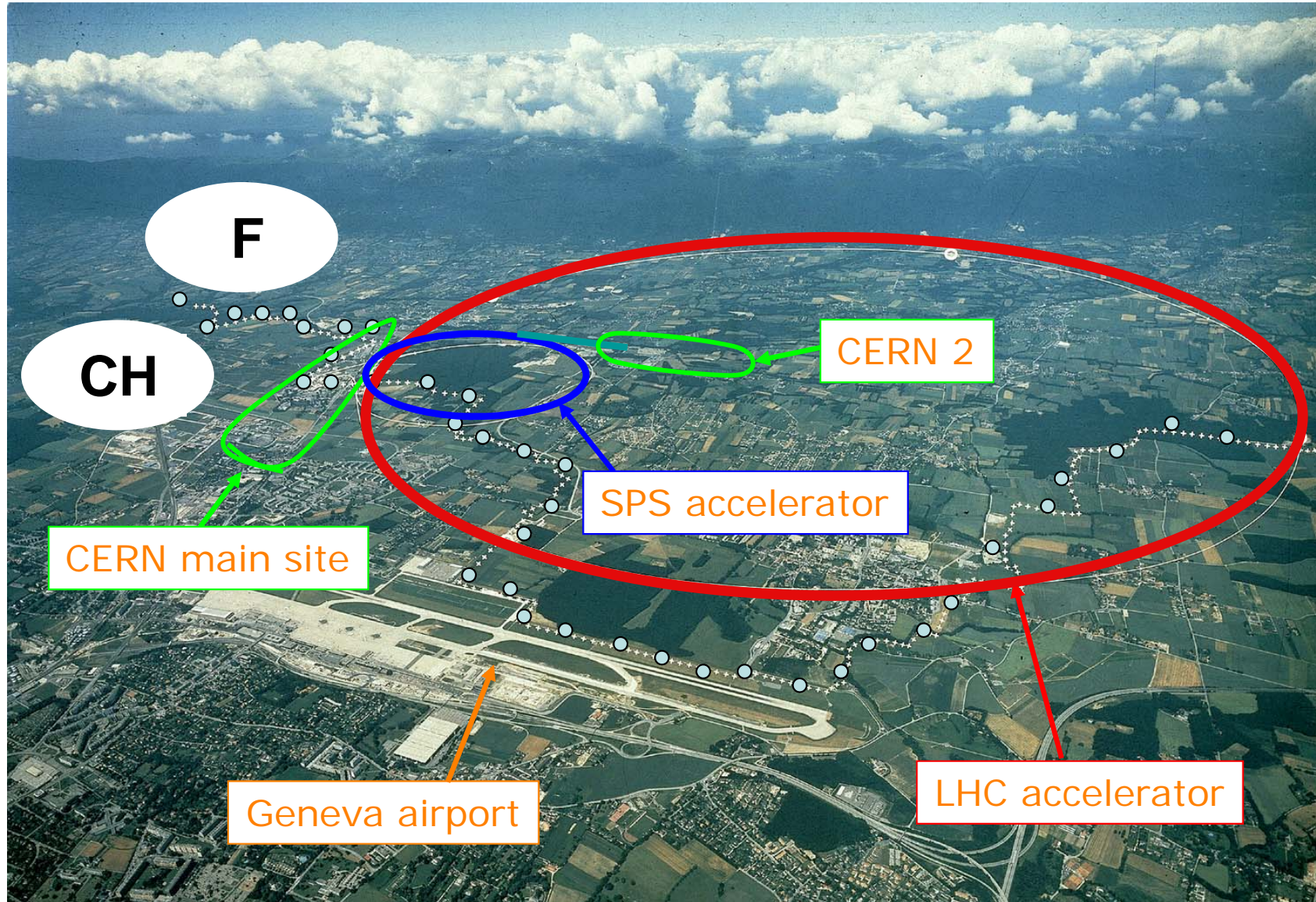
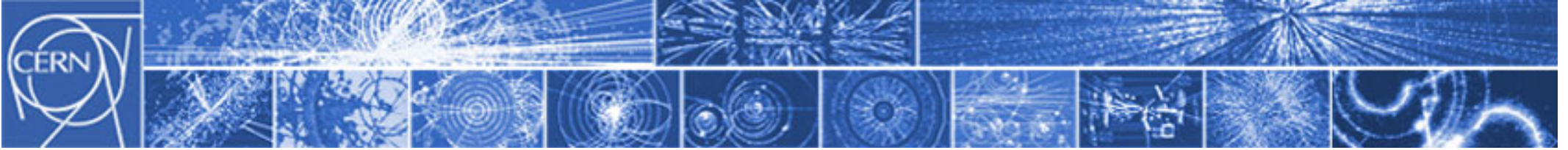


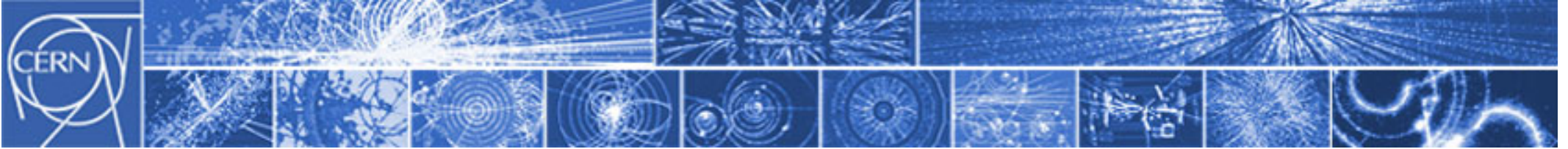
# The Hottest Place in the Galaxy



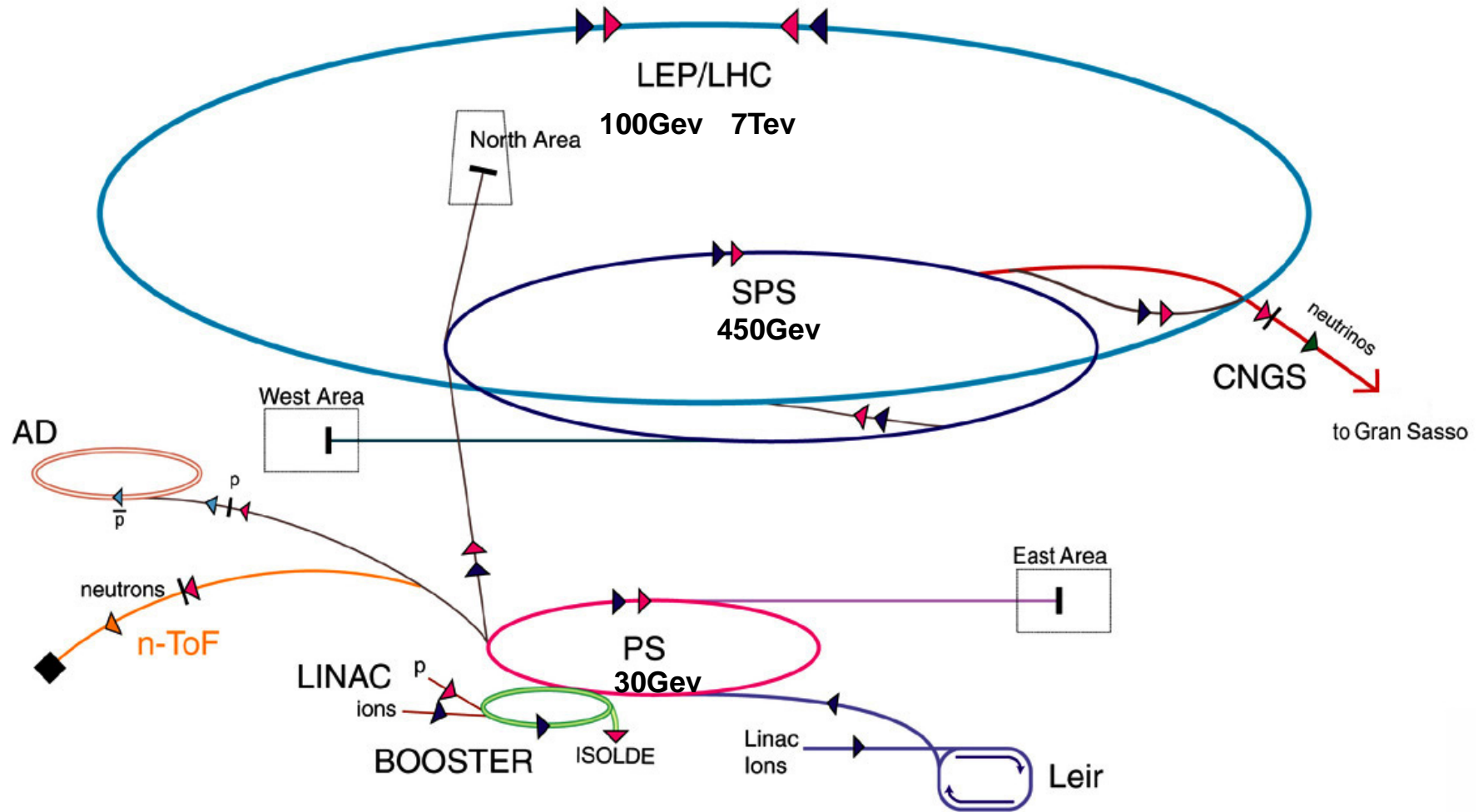
**Particle collisions create  
(within a tiny volume)  
temperatures a billion times higher than  
in the heart of the Sun**







# Accelerator chain at CERN, a complex business

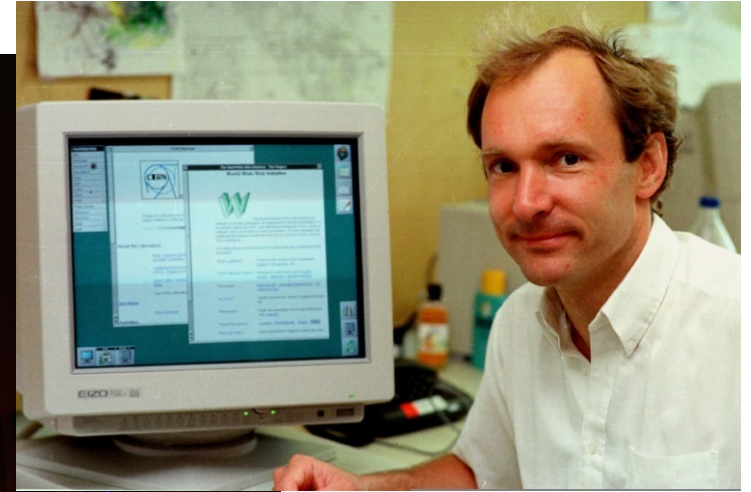
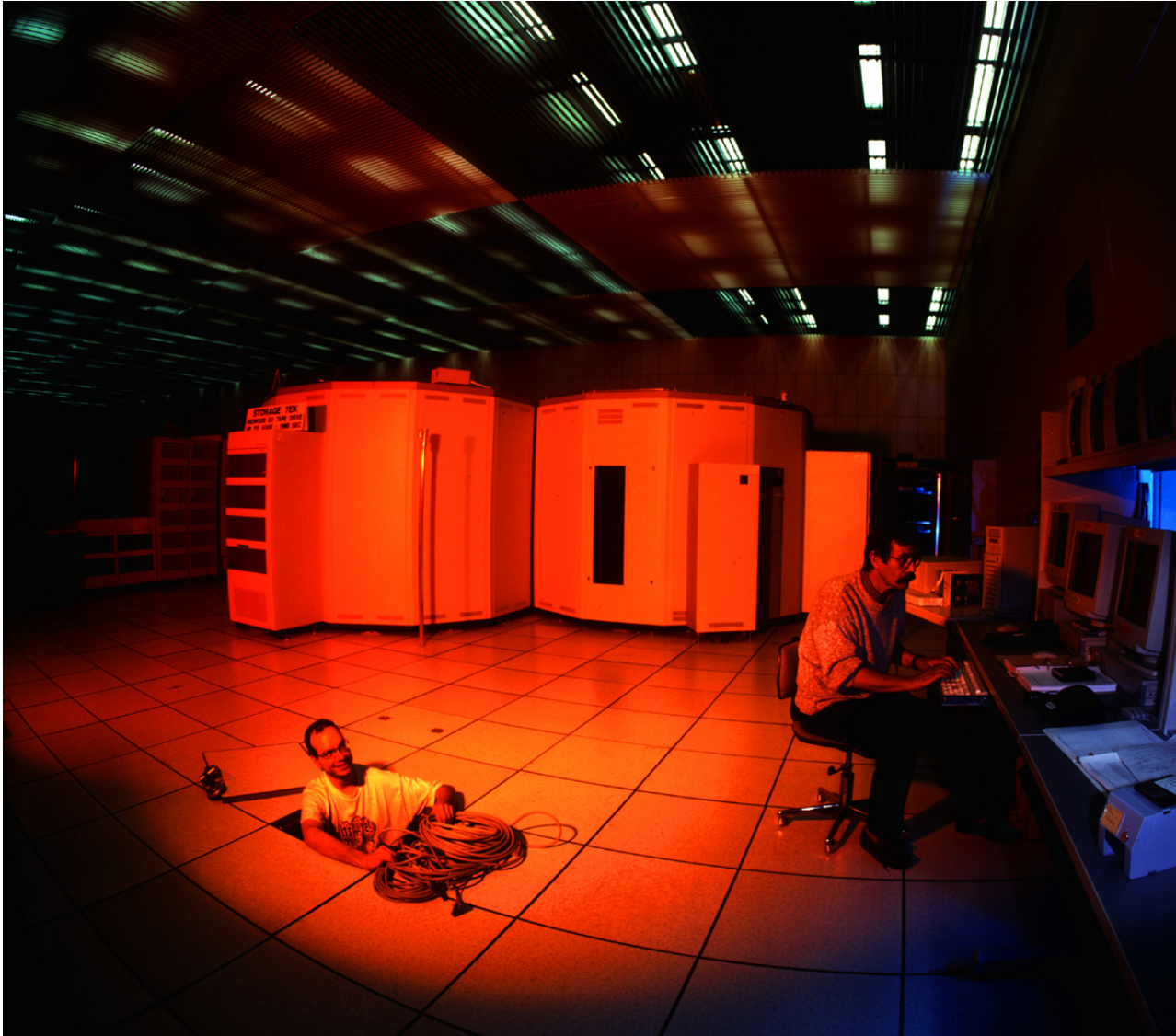


▶ p (proton)  
 ▶ ion  
 ▶ neutron

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

AD Antiproton Decelerator  
 PS Proton Synchrotron  
 SPS Super Proton Synchrotron

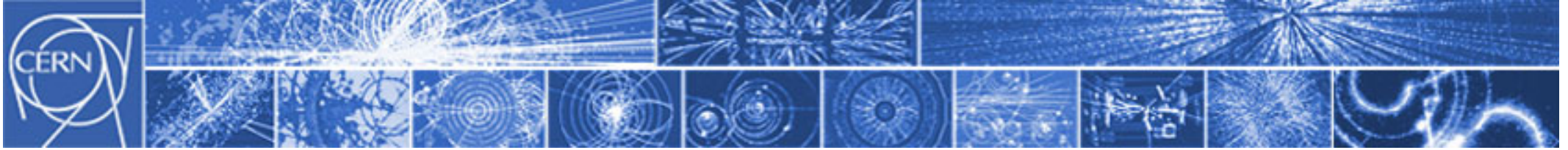
LHC Large Hadron Collider  
 n-ToF Neutron Time of Flight  
 CNGS Cern Neutrinos Gran Sasso



**Tim Berners-Lee**  
**World Wide Web**  
**1989**

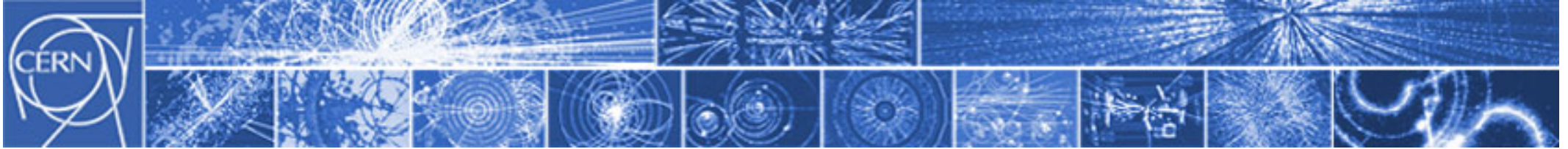
**[www.cern.ch](http://www.cern.ch)**

**Computing**  
**GRID**



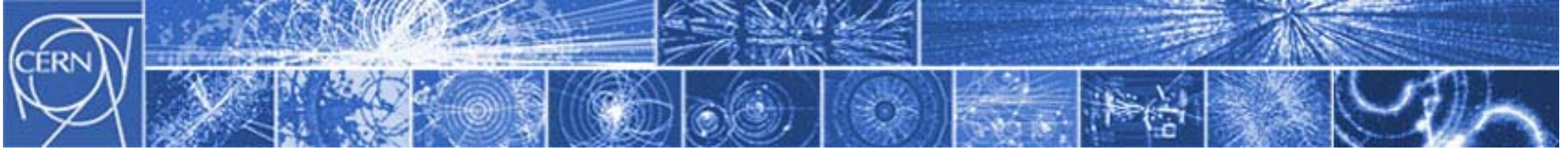
# Personnel





# Workforce

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



## CERN Education Activities

**Scientists at CERN**  
Academic Training Programme

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



**CERN Personnel**  
Training Programmes  
Language, Management, Technical



CERN School of Computing  
Uxbridge, UK, 2010

**Physics Students**  
Summer Students Programme



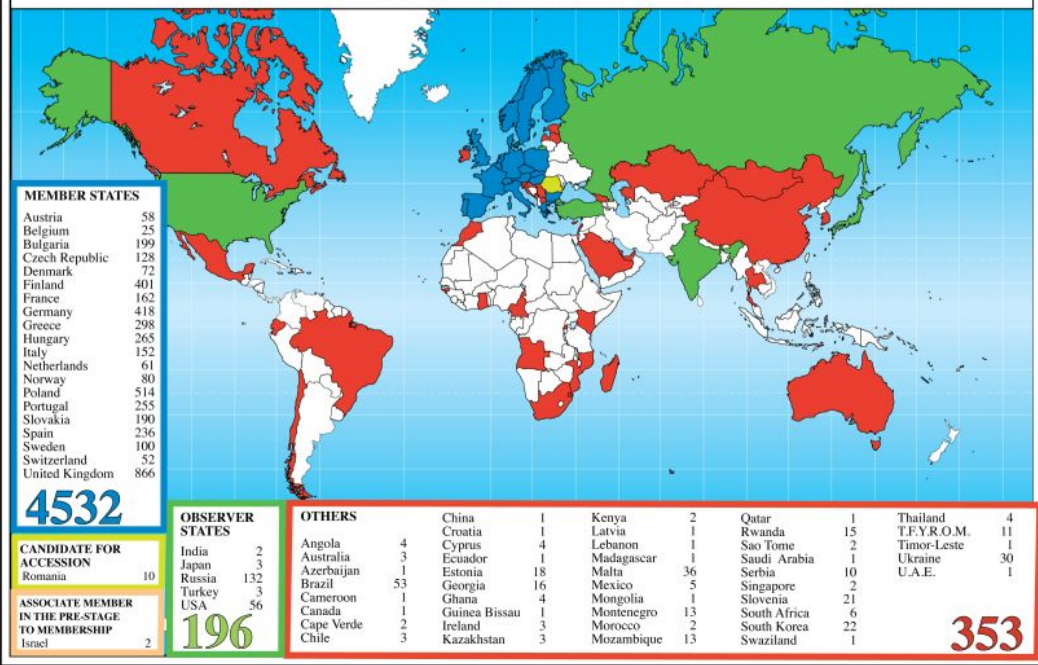
**CERN Teacher Schools**  
International and National Programmes





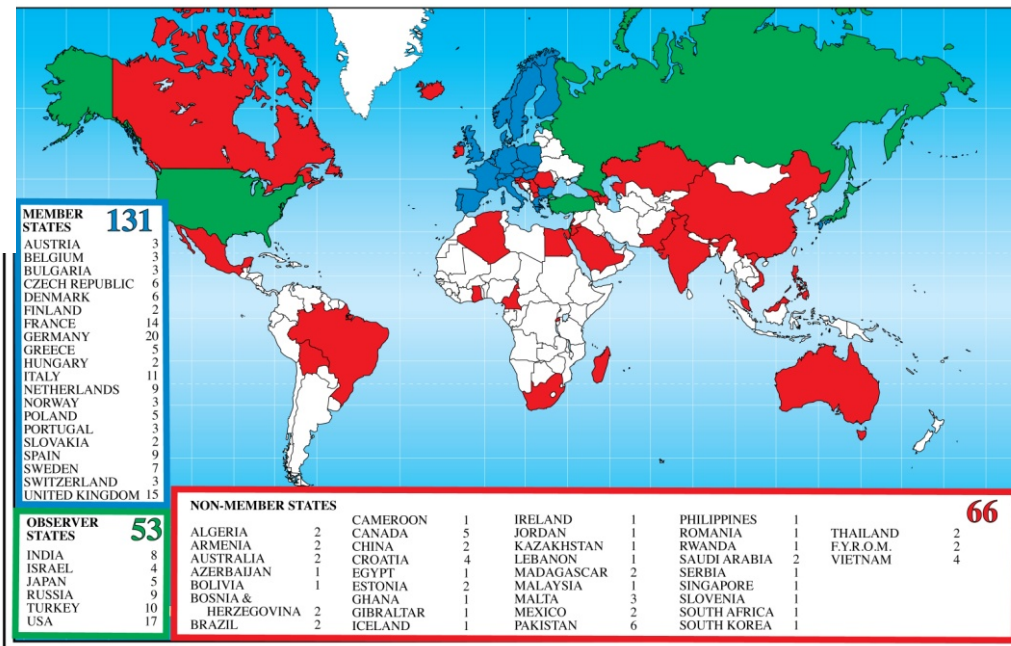
# CERN Education Activities

## CERN Teacher Programme Participants 1998 - 2011



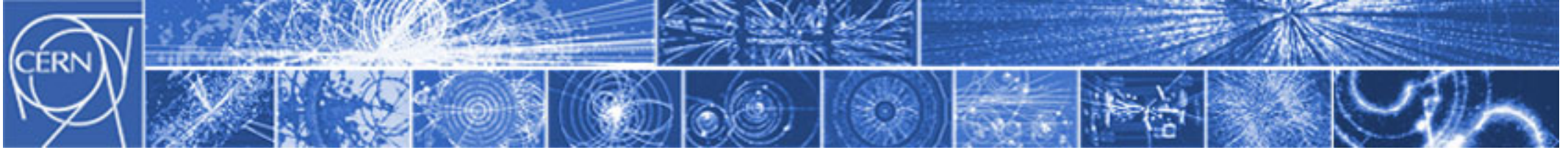
## CERN Teacher Programme Participants: 1998 – December 2011

## Distribution of Summer Students 2010



## CERN Summer Students in 2010





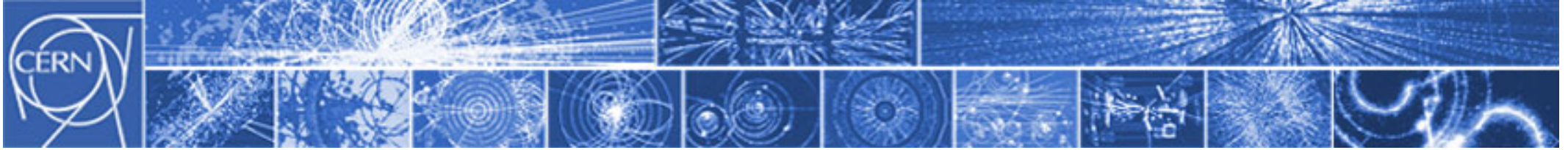
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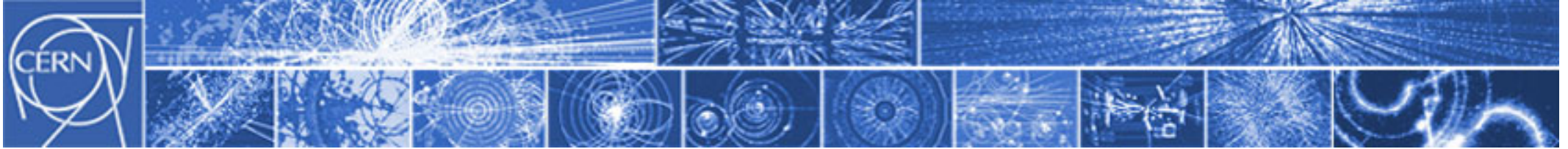


### What next ?





**OPERA experiment invites scrutiny of unexpected results**



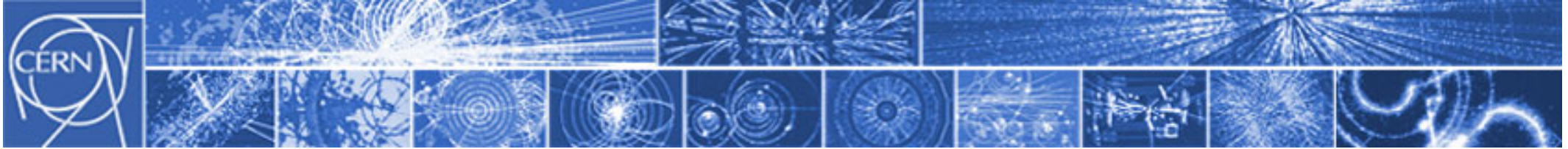
## ATLAS and CMS experiments present Higgs search status

13 December 2011. In a seminar held at CERN<sup>1</sup> today, the ATLAS<sup>2</sup> and CMS<sup>3</sup> 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<sup>1</sup> 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."*