CERN
&
THE LARGE HADRON COLLIDER
SHEDDING LIGHT ON THE DARK UNIVERSE

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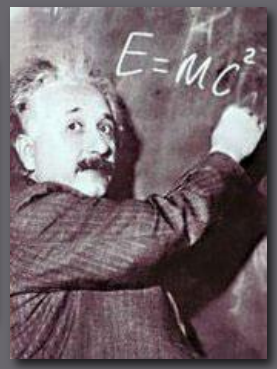
INTRODUCTION

The Mission of CERN



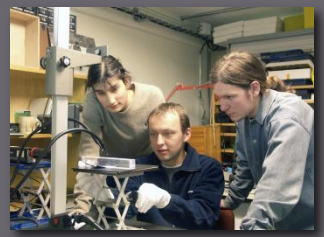
- Push back the frontiers of knowledge

  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

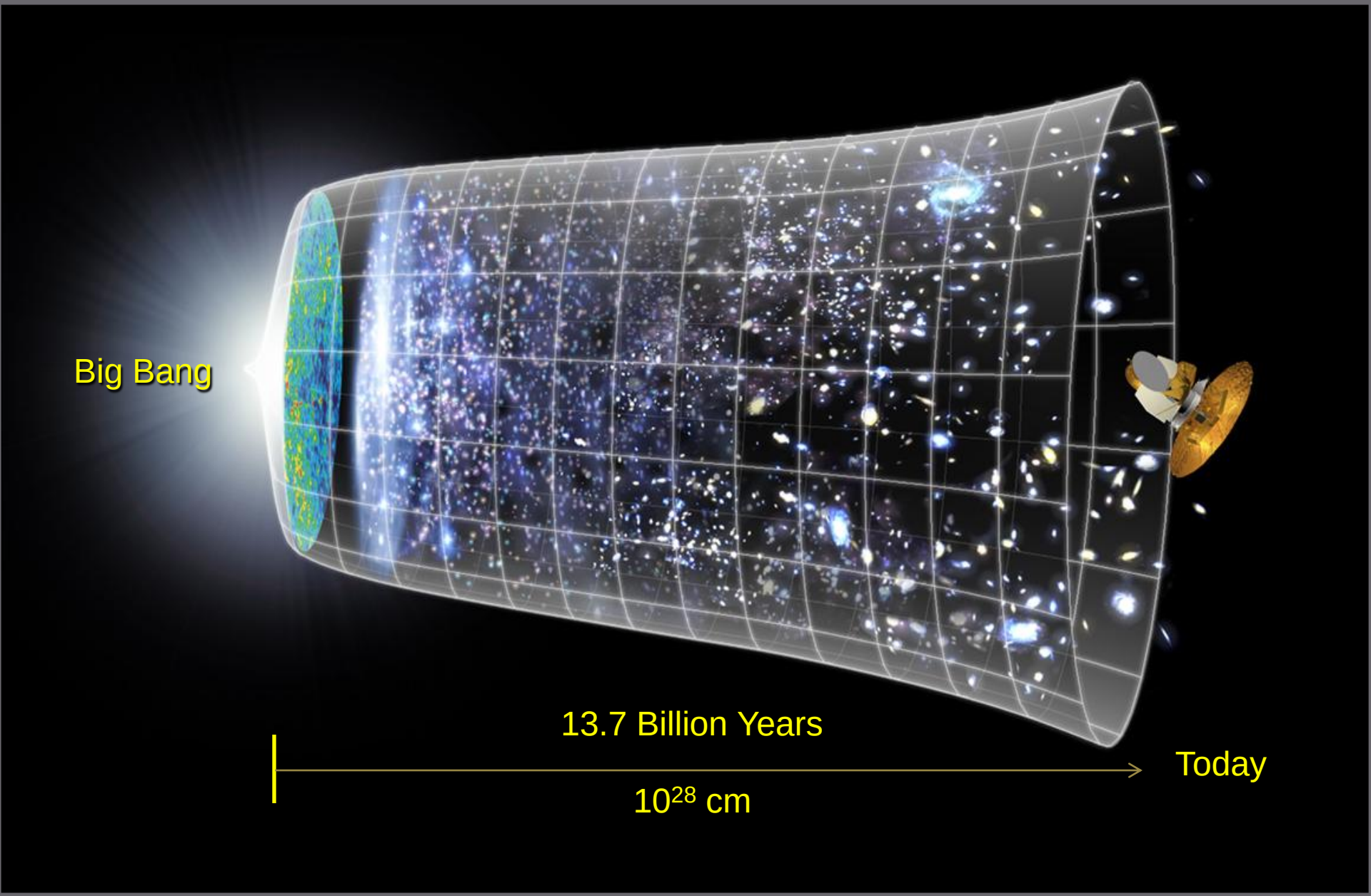
  Medicine - diagnosis and therapy

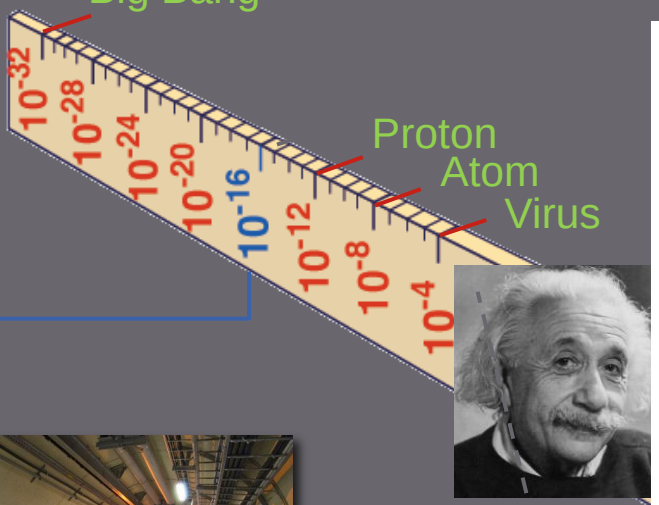


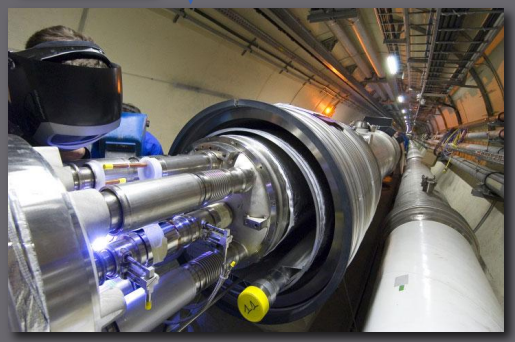
- Train scientists and engineers of tomorrow

- Unite people from different countries and cultures

Evolution of the Universe

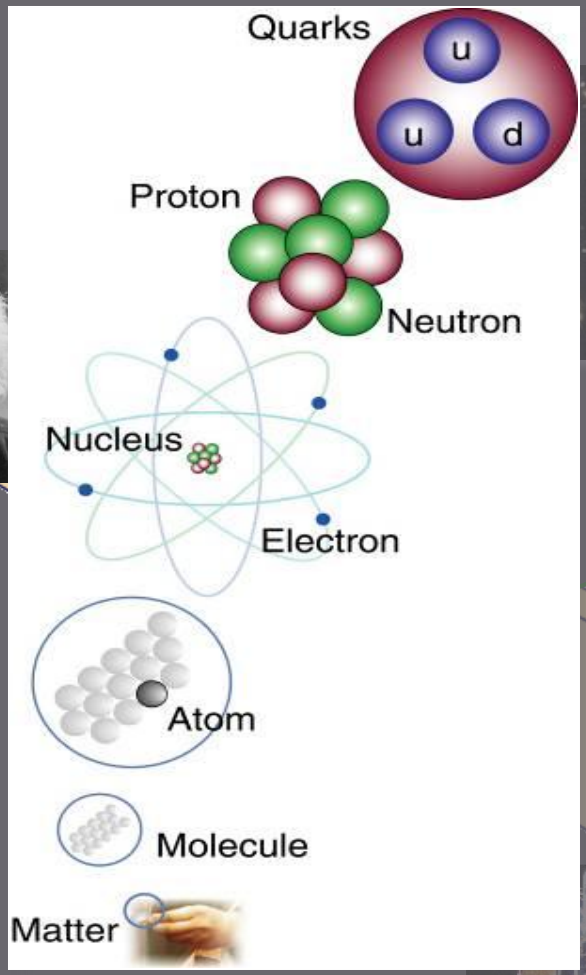




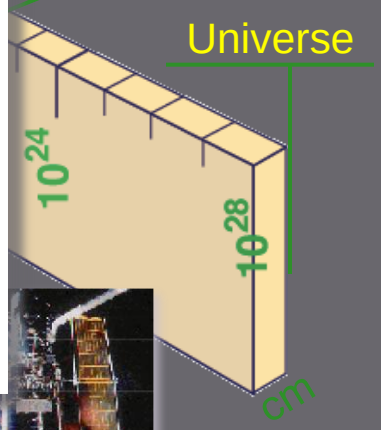


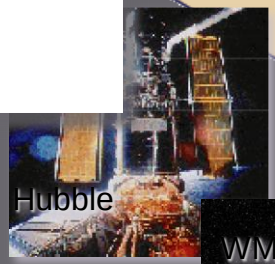
LHC

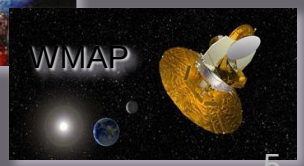
Super-Microscope



Radius of Galaxies

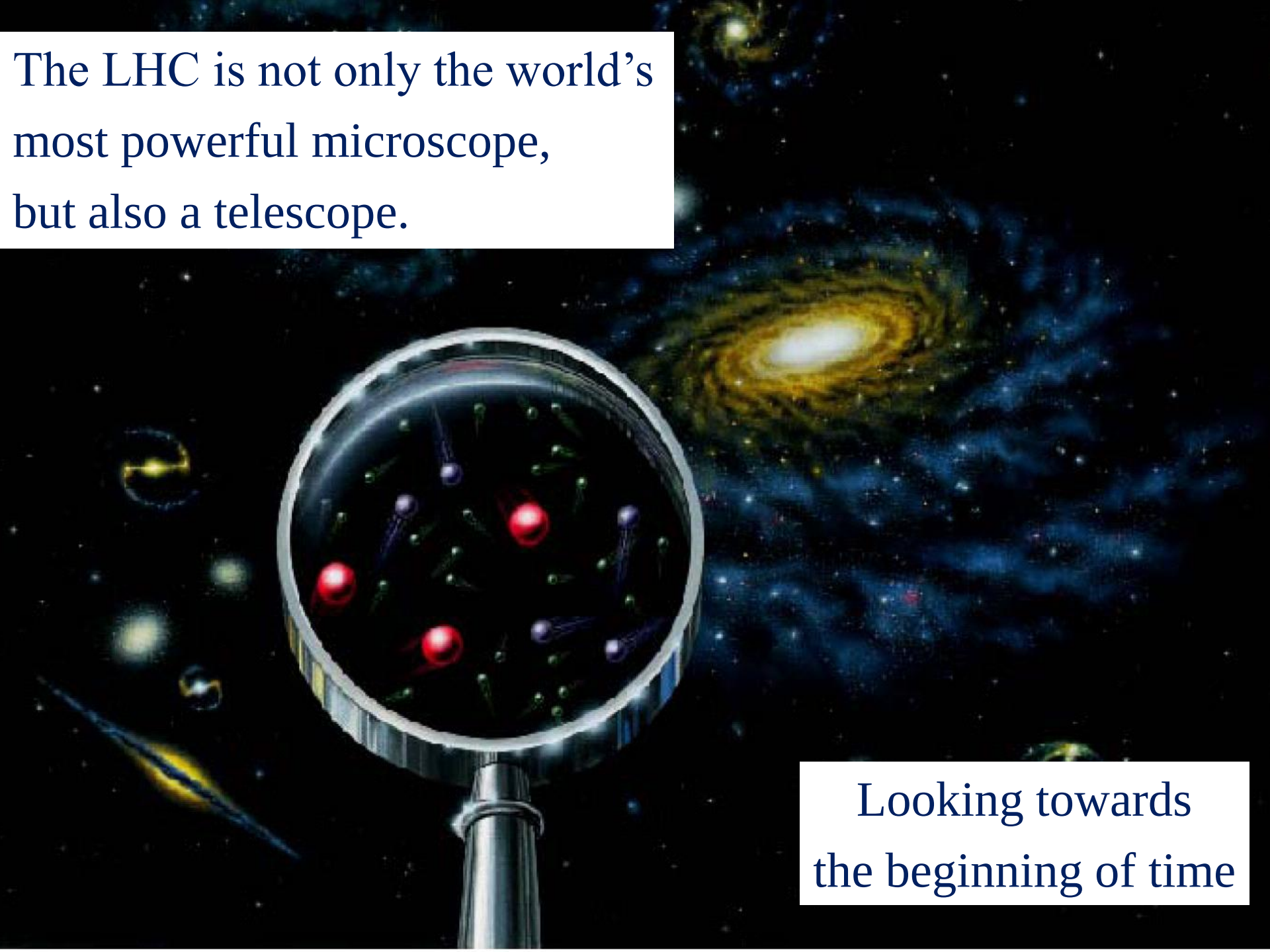






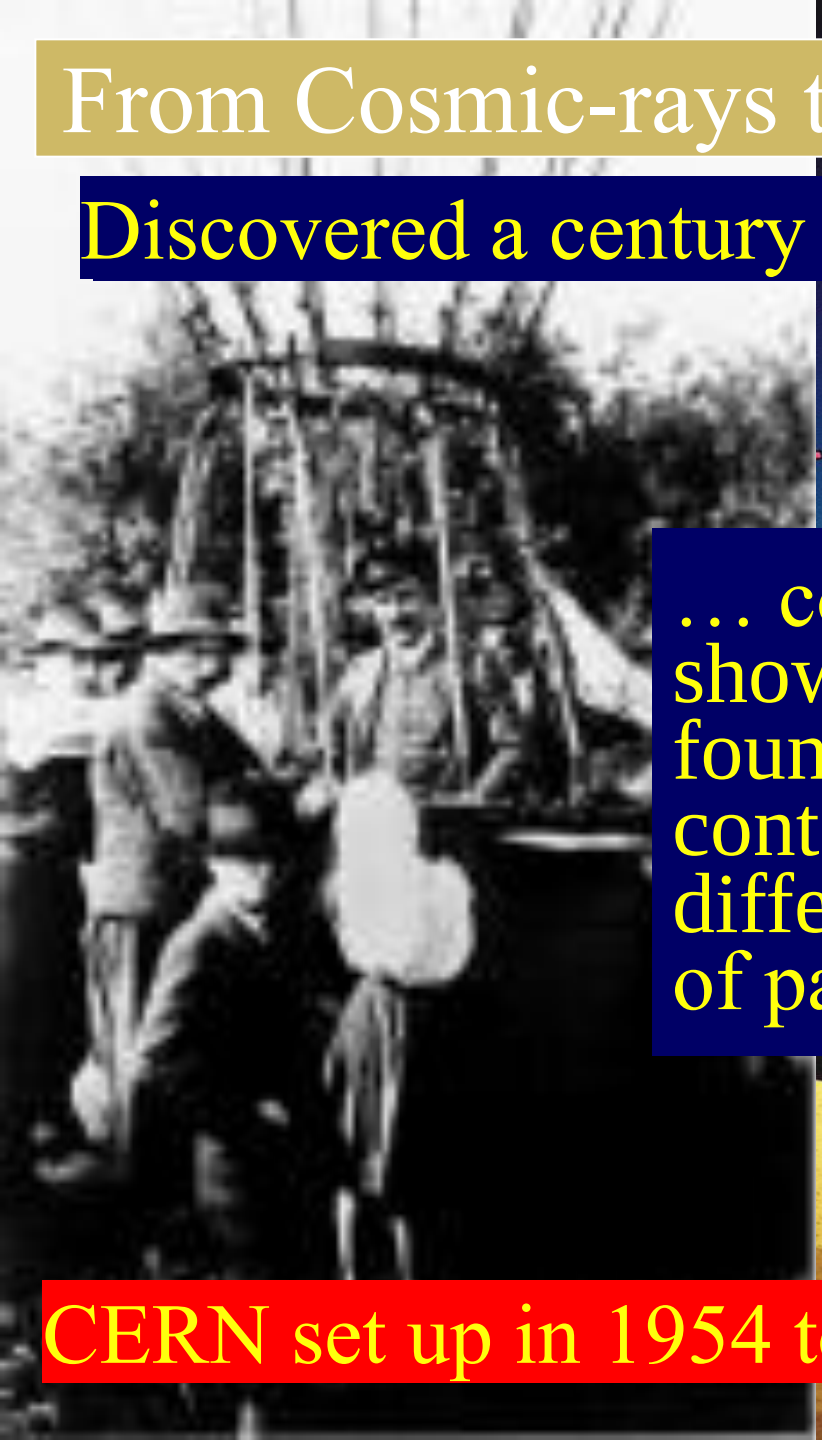
Study physics laws of first moments after Big Bang

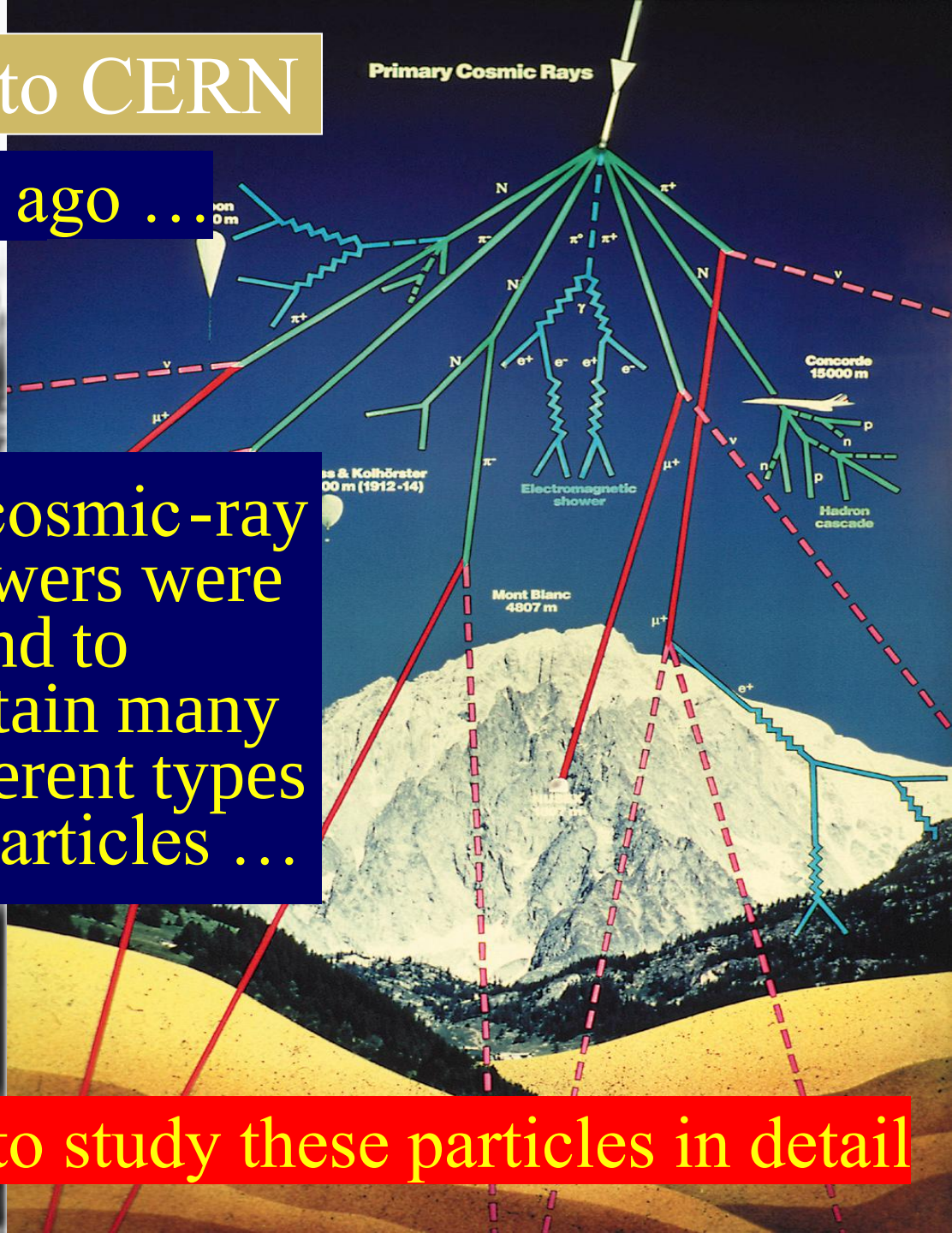
Increasing Symbiosis between Particle Physics, Astrophysics and Cosmology


The LHC is not only the world's most powerful microscope, but also a telescope.
Looking towards the beginning of time

From Cosmic-rays to CERN

Discovered a century ago …





… cosmic-ray showers were found to contain many different types of particles …

CERN set up in 1954 to study these particles in detail

The ‘Standard Model’

= Cosmic DNA

The matter particles

The fundamental interactions

Gravitation electromagnetism weak nuclear force strong nuclear force

Why do Things Weigh?

Newton:

Weight proportional to Mass

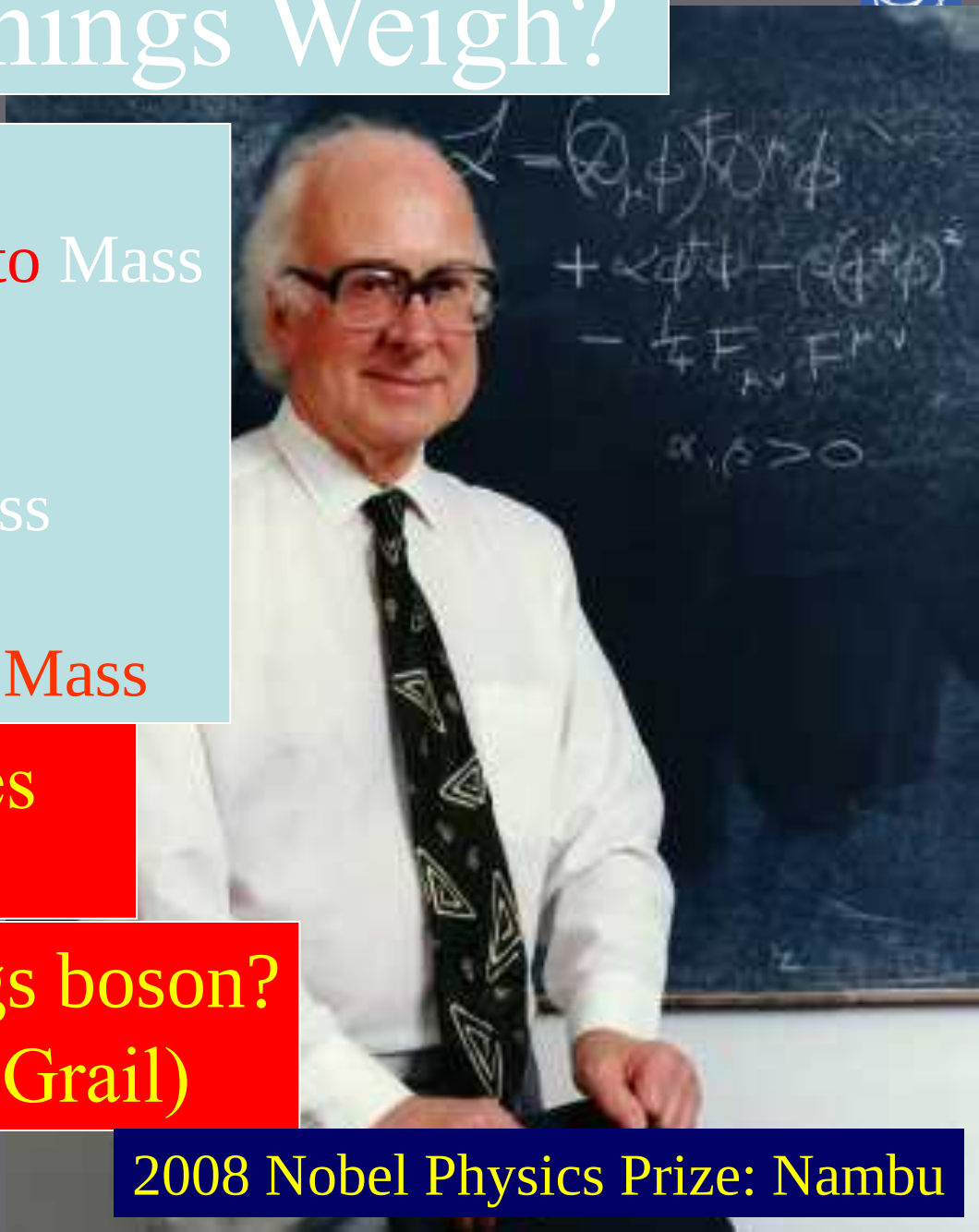
Einstein:

Energy related to Mass

Neither explained origin of Mass

Where do the masses come from?

Are masses due to Higgs boson? (the physicists' Holy Grail)



2008 Nobel Physics Prize: Nambu

Dark Matter in the Universe

Astronomers say that most of the matter in the Universe is invisible
Dark Matter

‘Supersymmetric’ particles ?

We shall look for them with the LHC

Where does the Matter come from?

Dirac predicted the existence of antimatter:
- same mass
- opposite internal properties:
  - electric charge, …

Discovered in cosmic rays

Studied using accelerators

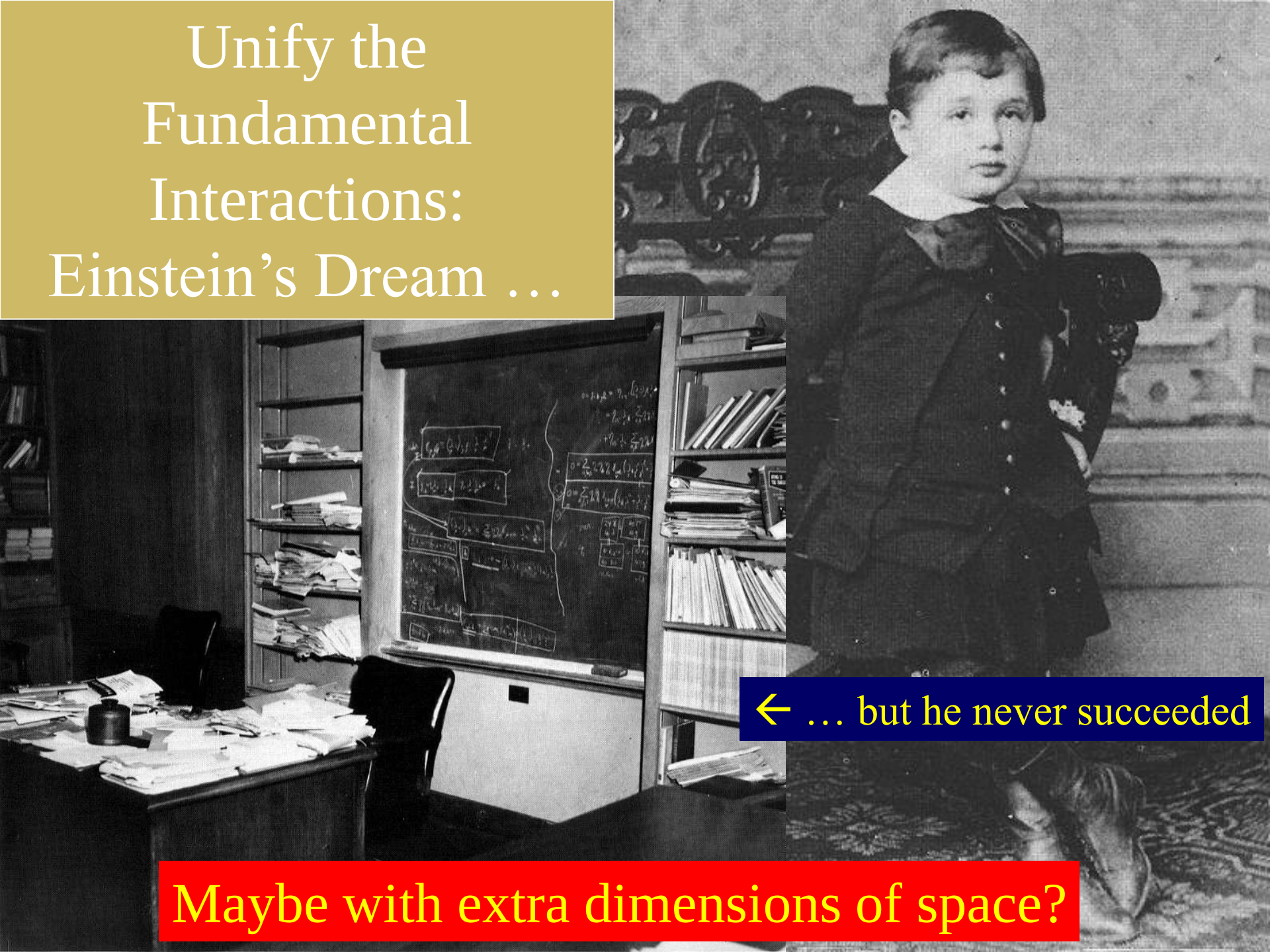
Matter and antimatter not quite equal and opposite: WHY?

2008 Nobel Physics Prize: Kobayashi & Maskawa

Is this why the Universe contains mainly matter, not antimatter?

LHC experiments will look for answer

Unify the Fundamental Interactions: Einstein's Dream …

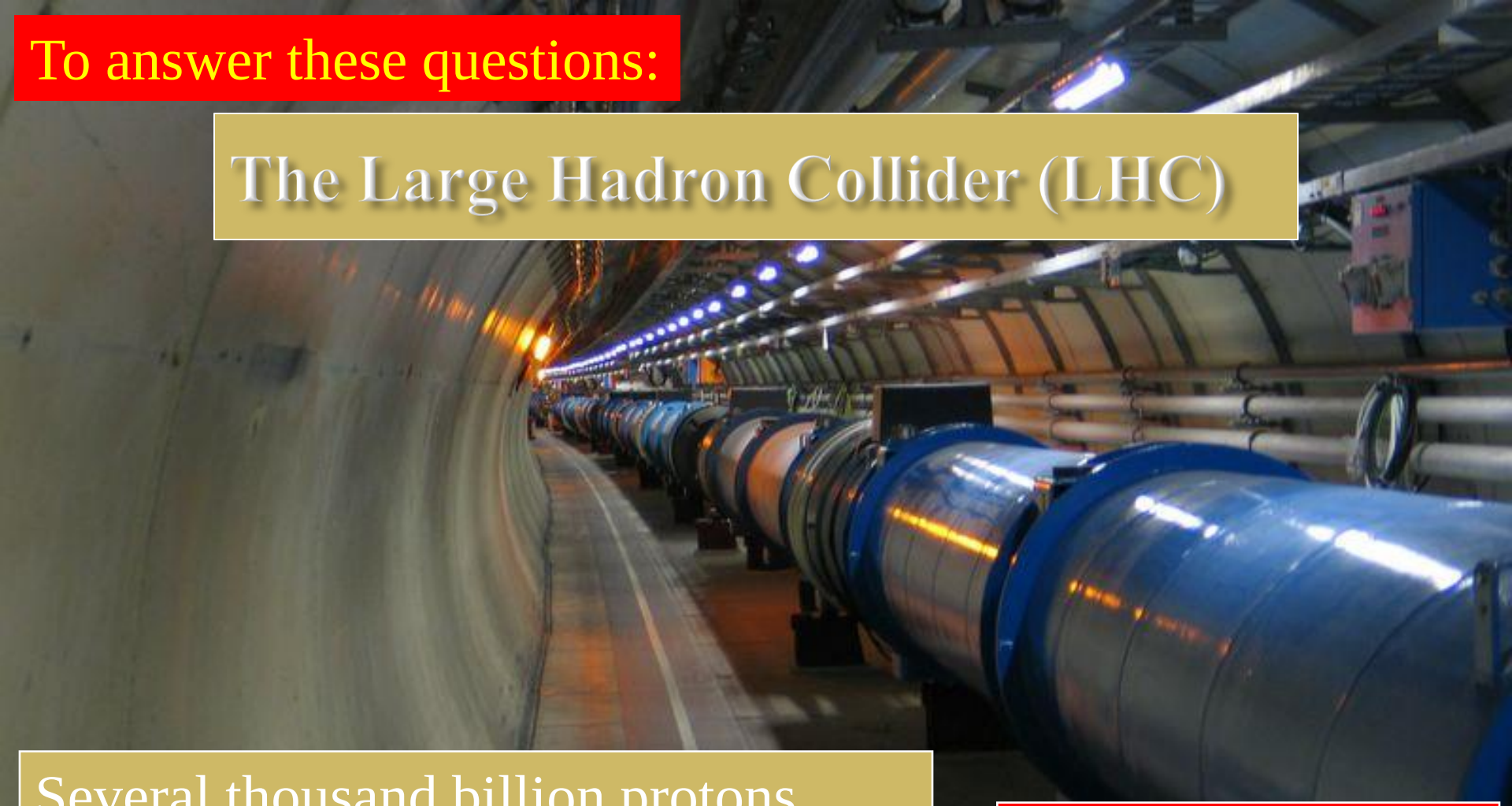


← … but he never succeeded

Maybe with extra dimensions of space?

To answer these questions:

The Large Hadron Collider (LHC)



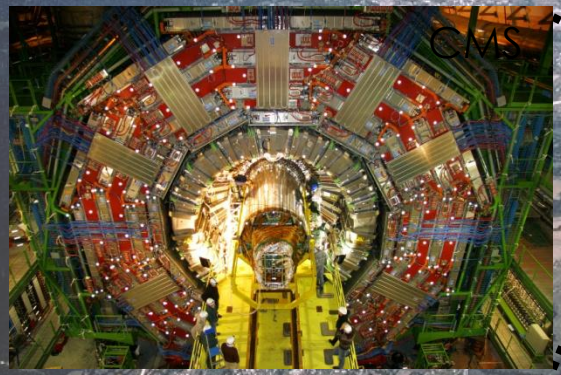
Several thousand billion protons
Each with the energy of a fly
99.9999991% of light speed
Orbit 27km ring 11 000 times/second
600 million collisions a second

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

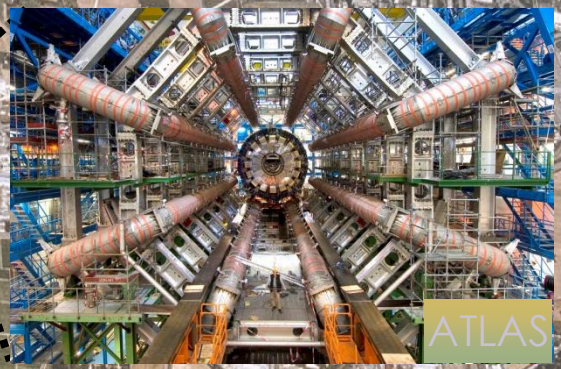
THE LARGE HADRON COLLIDER

Enter a New Era in Fundamental Science

Start-up of the Large Hadron Collider (LHC), one of the largest and truly global scientific projects ever, is the most exciting turning point in particle physics.

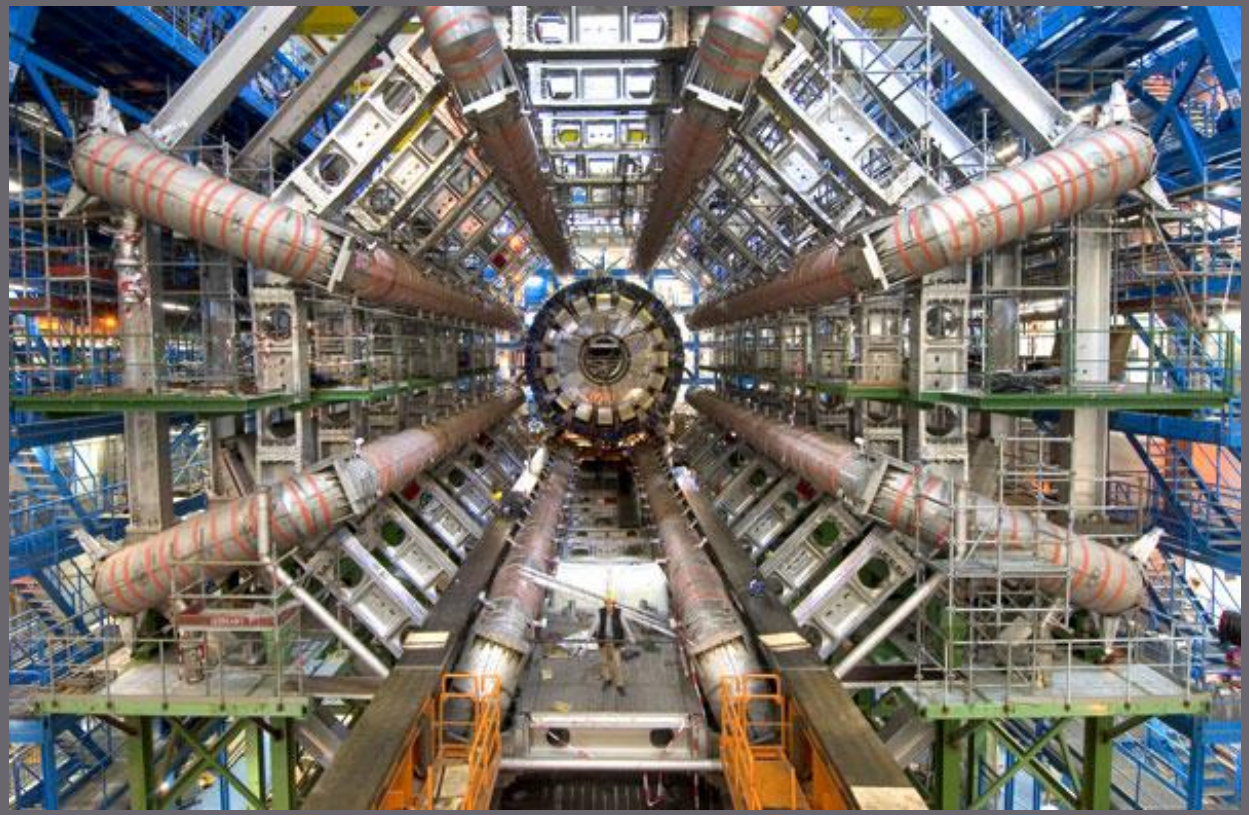


Exploration of a new energy frontier
Proton-proton collisions at E_{CM} = 14 TeV



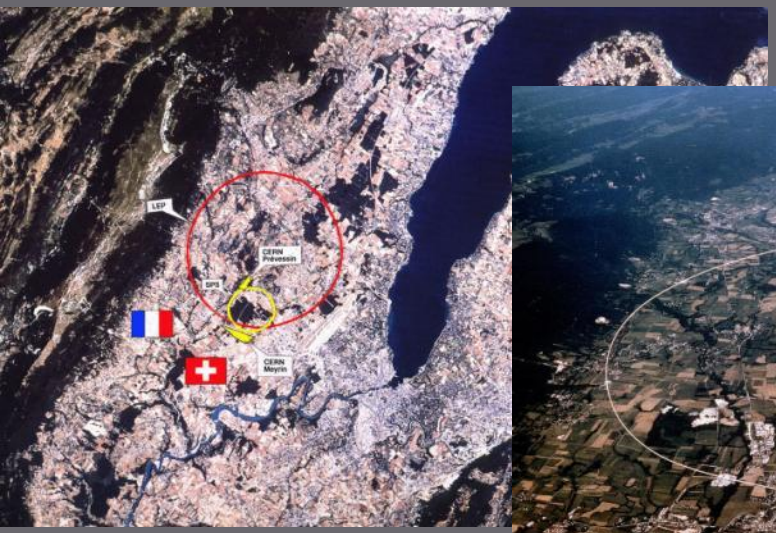
The Large Hadron Collider (LHC)

the largest and most complex detectors



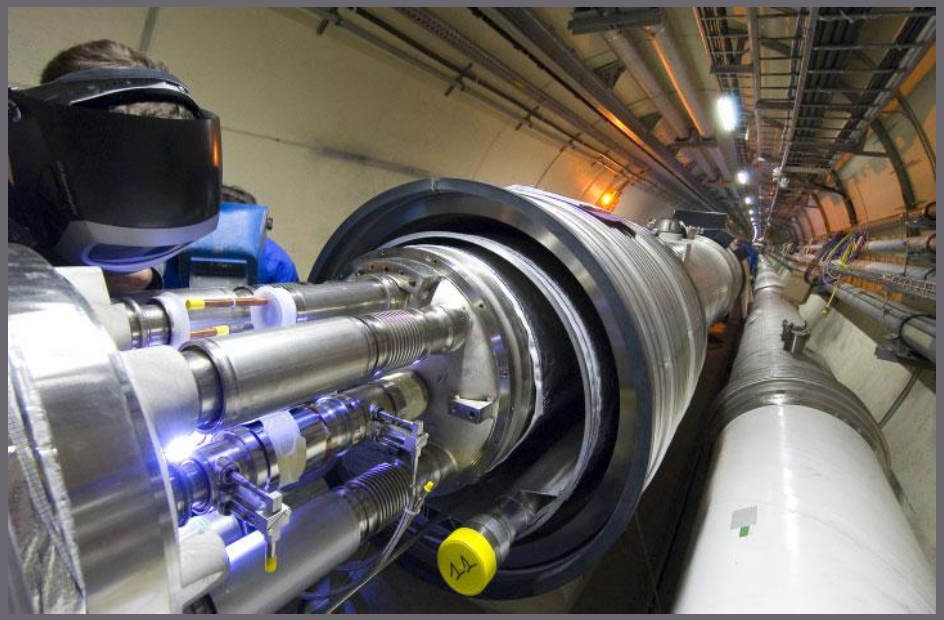
To select and record the signals from the 600 million proton collisions every second, huge detectors have been built to measure the particles traces to an extraordinary precision.

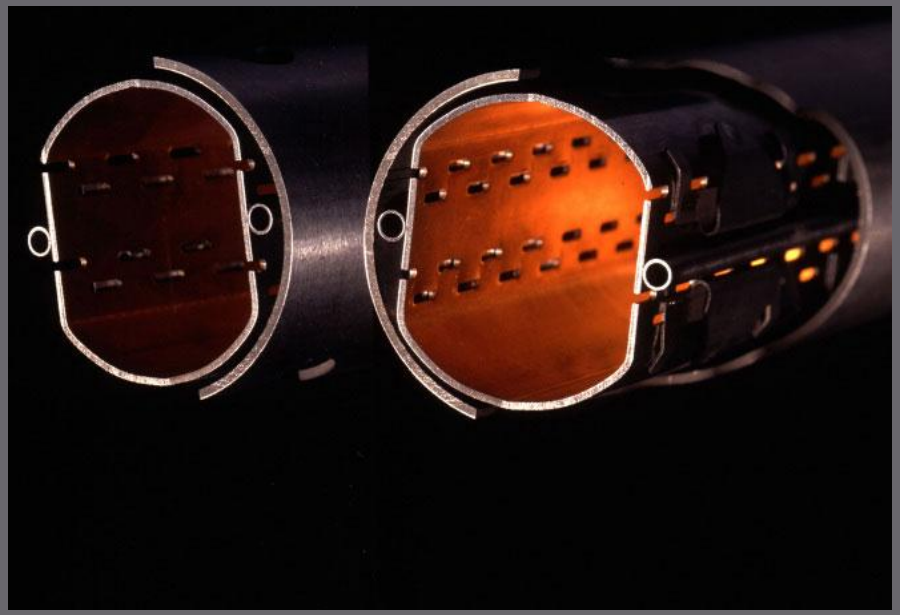
The fastest racetrack on the planet…



Trillions of protons will race around the 27km ring in opposite directions over 11,000 times a second, travelling at 99.999999991 per cent the speed of light.

The emptiest space in the solar system…



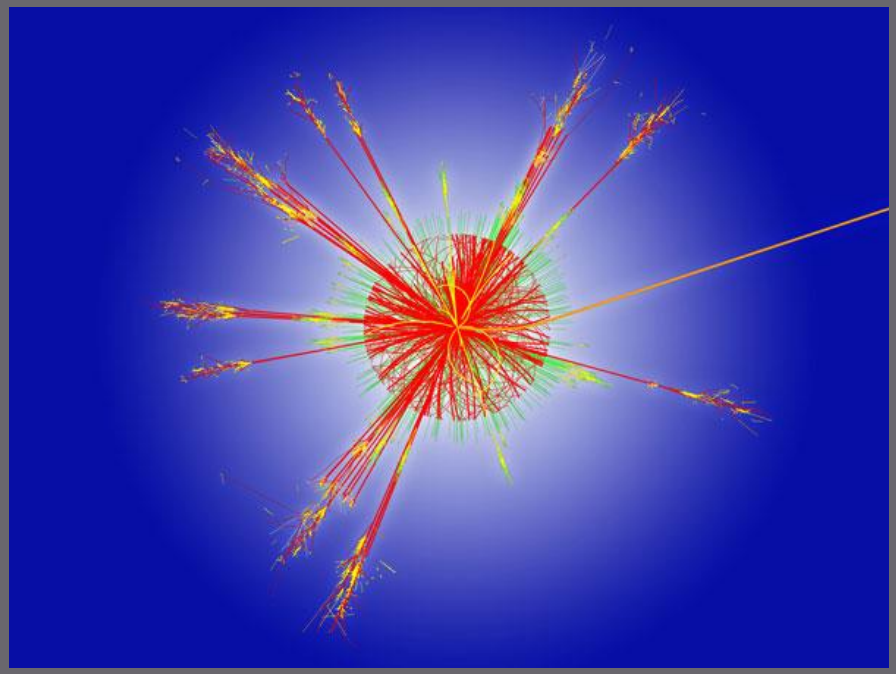


To accelerate protons to almost the speed of light requires a vacuum as empty as interplanetary space. There is 10 times more atmosphere on the moon than there is in the LHC.

One of the coldest places in the universe…

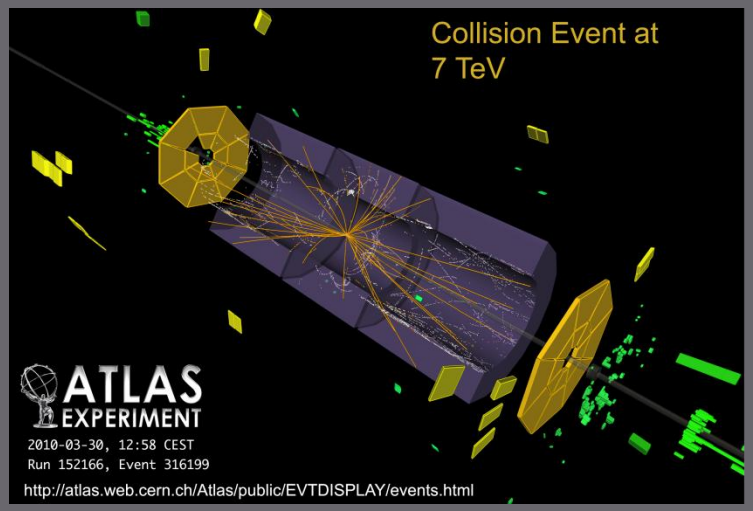
With an operating temperature of about -271 degrees Celsius, just 1.9 degrees above absolute zero, the LHC is colder than outer space.

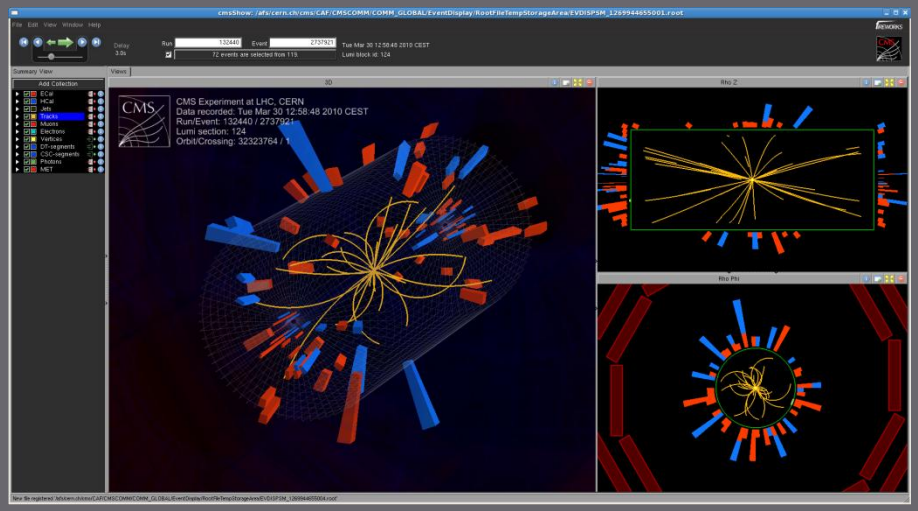
The hottest spots in the galaxy…

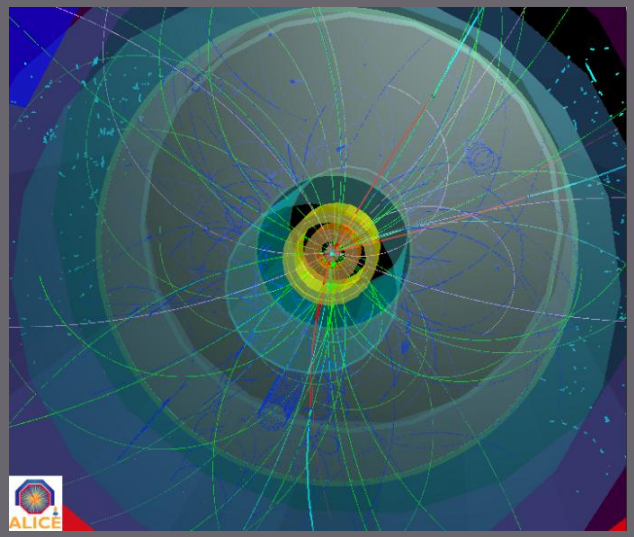


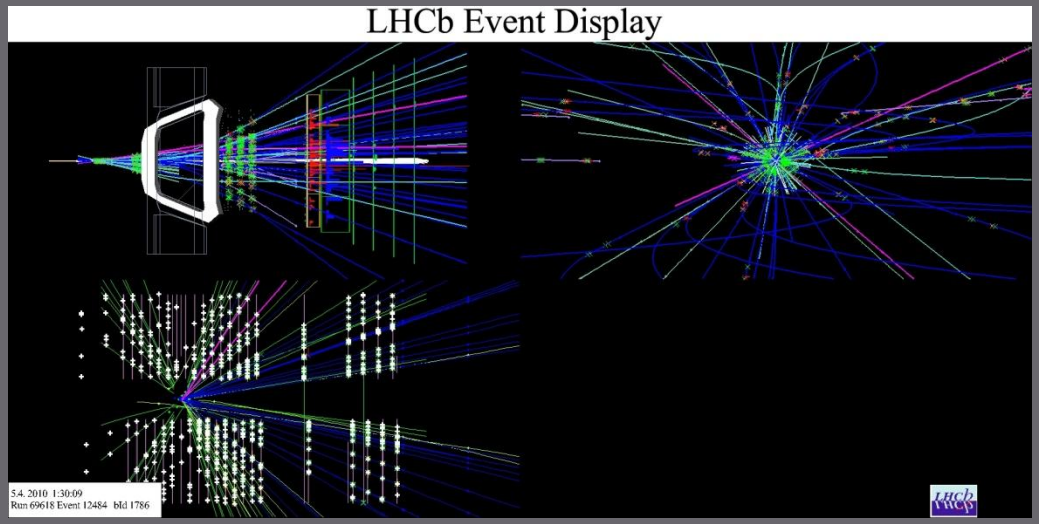
When two beams of protons collide, they will generate temperatures 1000 million times hotter than the heart of the sun, but in a minuscule space.

LHC Started 7-TeV Collisions on 30 March 2010









A billion people watched on TV

The LHC Enters Popular Culture

CERN
EUROPEAN LABORATORY FOR PARTICLE PHYSICS

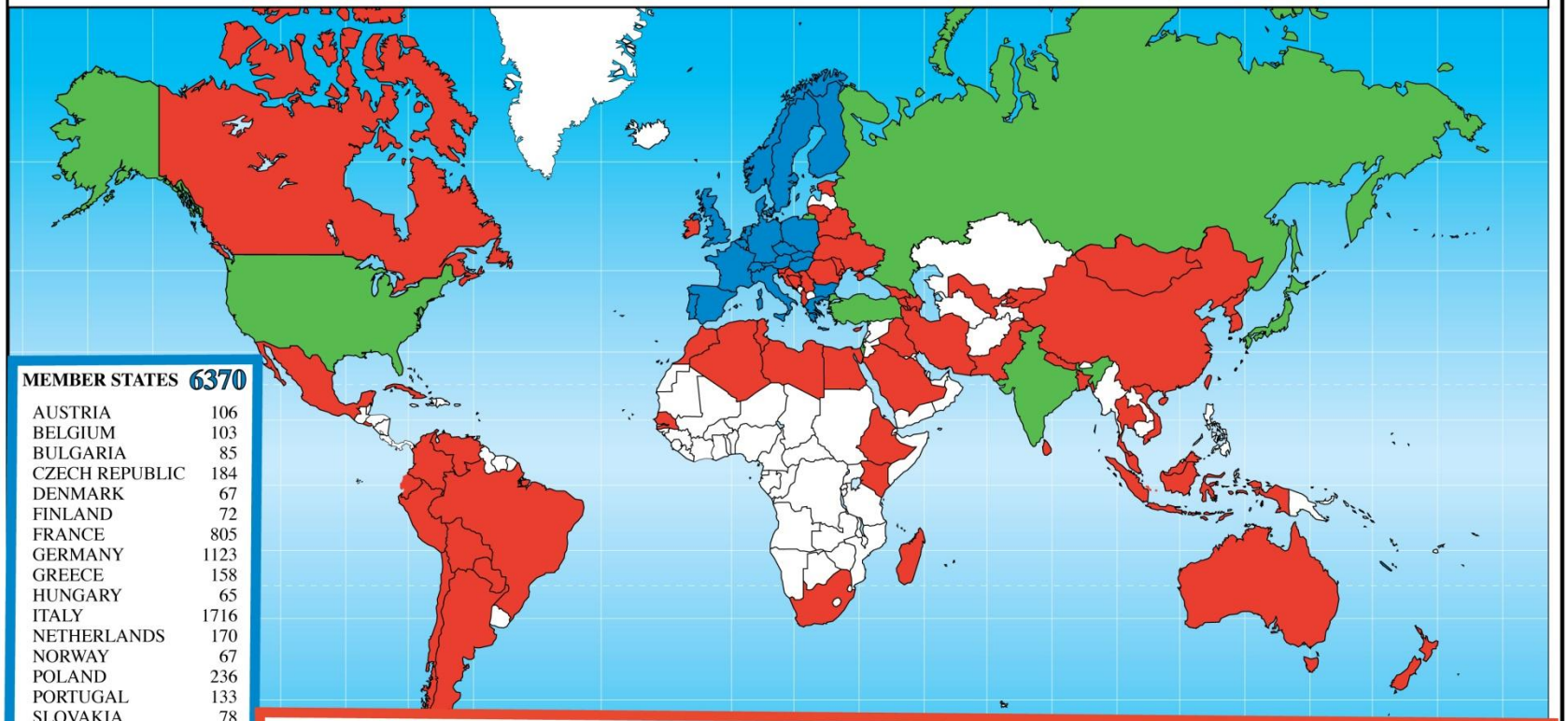
CERN was founded 1954: by 12 European States
Today: 20 Member States

- ~ 2340 staff
- ~ 840 other paid personnel
- > 10000 users
- Budget (2010) ~1100 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.
- 1 Candidate for Accession to Membership of CERN: Romania
- 5 Applicants for Membership of CERN: Cyprus, Israel, Serbia, Slovenia, Turkey
- 8 Observers to Council: India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO
- New status of Associate Membership

Breaking the Walls between Cultures and Nations since 1954

Distribution of All CERN Users by Nationality on 20 January 2010



MEMBER STATES 6370

AUSTRIA	106
BELGIUM	103
BULGARIA	85
CZECH REPUBLIC	184
DENMARK	67
FINLAND	72
FRANCE	805
GERMANY	1123
GREECE	158
HUNGARY	65
ITALY	1716
NETHERLANDS	170
NORWAY	67
POLAND	236
PORTUGAL	133
SLOVAKIA	78
SPAIN	330
SWEDEN	67
SWITZERLAND	200
UNITED KINGDOM	605

OBSERVER STATES 2444

INDIA	158
ISRAEL	51
JAPAN	229
RUSSIA	1027
TURKEY	87
USA	892

OTHERS 1205

ALBANIA	2	BRAZIL	79	ESTONIA	9	KYRGYZSTAN	1	MOROCCO	16
ALGERIA	8	CANADA	136	ETHIOPIA	1	LEBANON	8	NEPAL	3
ARGENTINA	11	CHILE	3	GEORGIA	31	LITHUANIA	9	NEW ZEALAND	10
ARMENIA	24	CHINA	202	GIBRALTAR	1	LUXEMBOURG	5	PAKISTAN	33
AUSTRALIA	20	CHINA (TAIPEI)	41	HONG KONG	2	LIBYA	1	PA	
AZERBAIJAN	5	COLOMBIA	19	INDONESIA	1	MADAGASCAR	3	PE	
BANGLADESH	3	CROATIA	24	IRAN	20	MALAYSIA	7	ROMANIA	101
BELARUS	36	CUBA	4	IRAQ	1	MALTA	3	SAN MARINO	1
BOLIVIA	2	CYPRUS	12	IRELAND	20	MAURITIUS	1	SAUDI ARABIA	2
BOSNIA AND HERZEGOVINA	1	ECUADOR	2	KENYA	2	MEXICO	46	SENEGAL	1
		EGYPT	6	KOREA, D.P.R.	3	MOLDOVA	1	SERBIA	34
		EL SALVADOR	1	KOREA REP.	85	MONGOLIA	1	SINGAPORE	1
								SLOVENIA	20
								SOUTH AFRICA	9
								SRI LANKA	6
								SYRIA	2
								THAILAND	1
								TUNISIA	5
								UKRAINE	40
								UZBEKISTAN	2
								VENEZUELA	5
								VIET NAM	6

Thailand and CERN

Visits to CERN of
Her Royal Highness Maha Chakri Sirindhorn

18 May 2000: visit to the DELPHI experiment (LEP)

8 December 2003:
HRH presented a keynote speech at the conference
“The Role of Science in the Information Society (RSIS)”

16 March 2009:
Visit to the CMS experiment

Thailand and CERN

December 2008: visit of members from CERN to Thailand
October 2009: follow-up visit

Main scientific contacts with

Chulalongkorn University (Burin Asavapibhop)
Mahidol University (John David Ruffalo)
Suranaree University of Technology (Chinorat Kobdaj, Head School of Physics)
Synchrotron Light Research Institute (Directors)

Collaboration with CMS experiment:

- The CERN & CMS Collaboration has hosted several students from Thailand in the framework of the CERN Summer Student programme.
- PhD student Norraphat Srimanobhas (Chulalongkorn University), bi-doctoral project with the University of Antwerp (Albert De Roeck supervisor).

Teachers from Thailand participated in CERN High School Teachers programme 2010.

Thailand and CERN

Foster closer scientific collaboration between Thailand and CERN

Expression of Interest signed in March 2009:

Participation of Physicists from Universities and Research Institutes from Thailand in the CMS Experiment at the CERN LHC Accelerator

Thailand and CERN

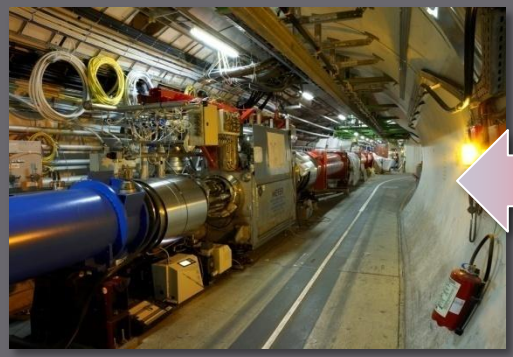
Visit of Her Royal Highness Maha Chakri Sirindhorn to CERN in April 2010

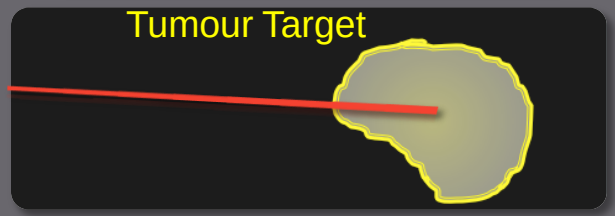
CERN Technologies - Innovation

Medical imaging

Example: medical application

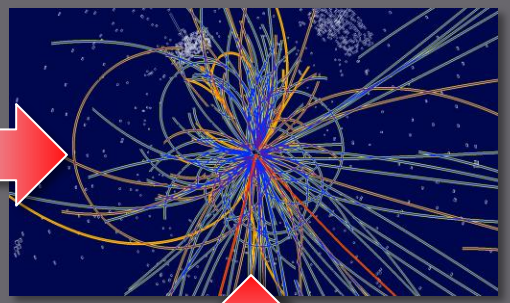
Accelerating particle beams

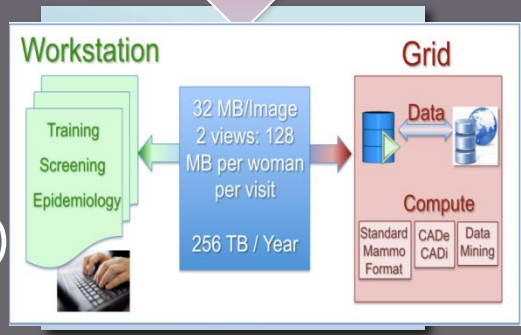




Charged hadron beam that loses energy in matter

Detecting particles

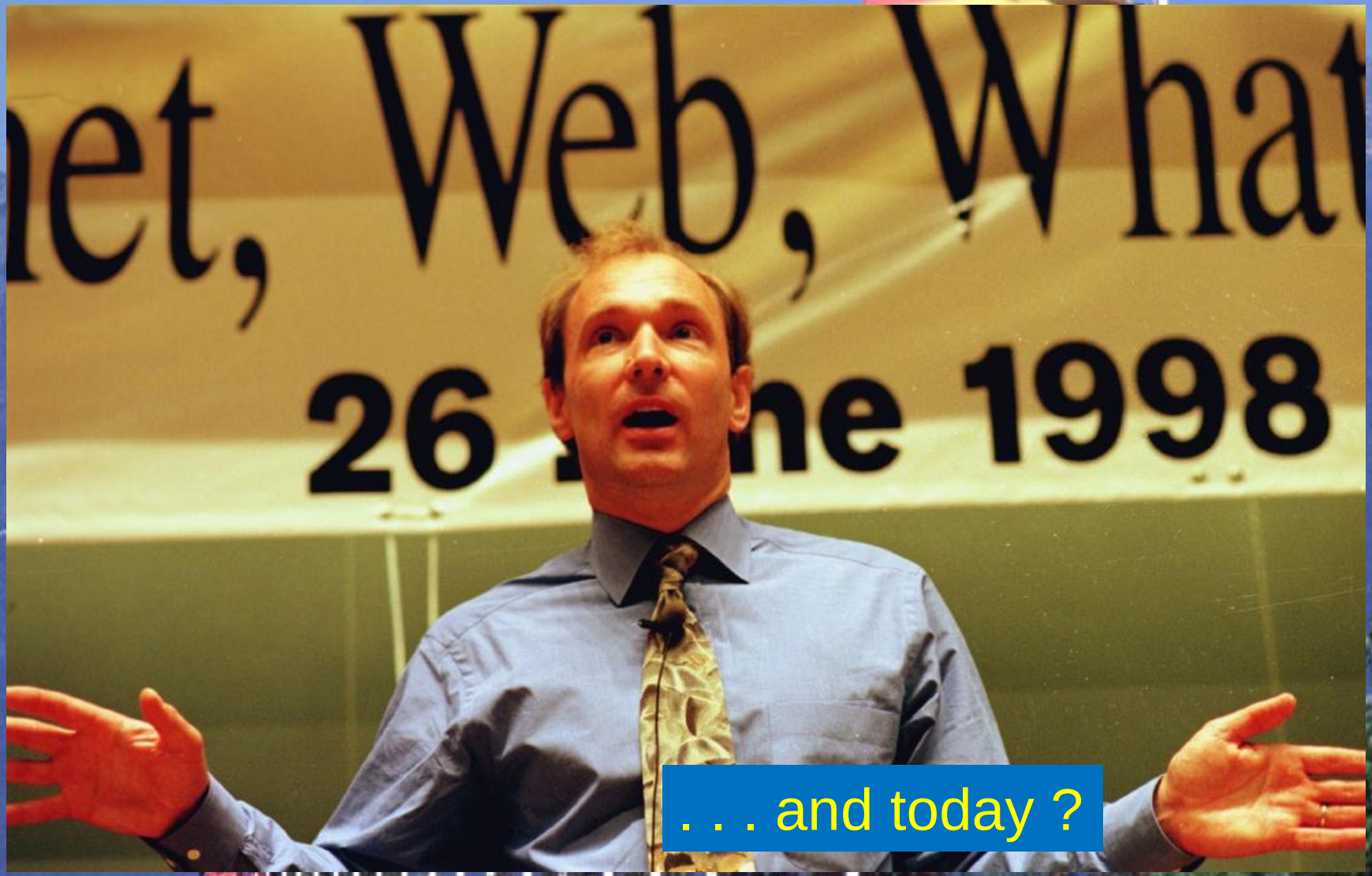




Large-scale **computing** (Grid)

Grid computing for medical data management and analysis

Breaking the Wall of Communication
20 years ago: the Web was born



LARGEST COMPUTER SYSTEM IN THE WORLD

100,000 computers all over the world
linked to analyse data from CERN
Grid is next advance in decentralised computing -
from laboratory that invented the World-Wide Web

CERN Education Activities

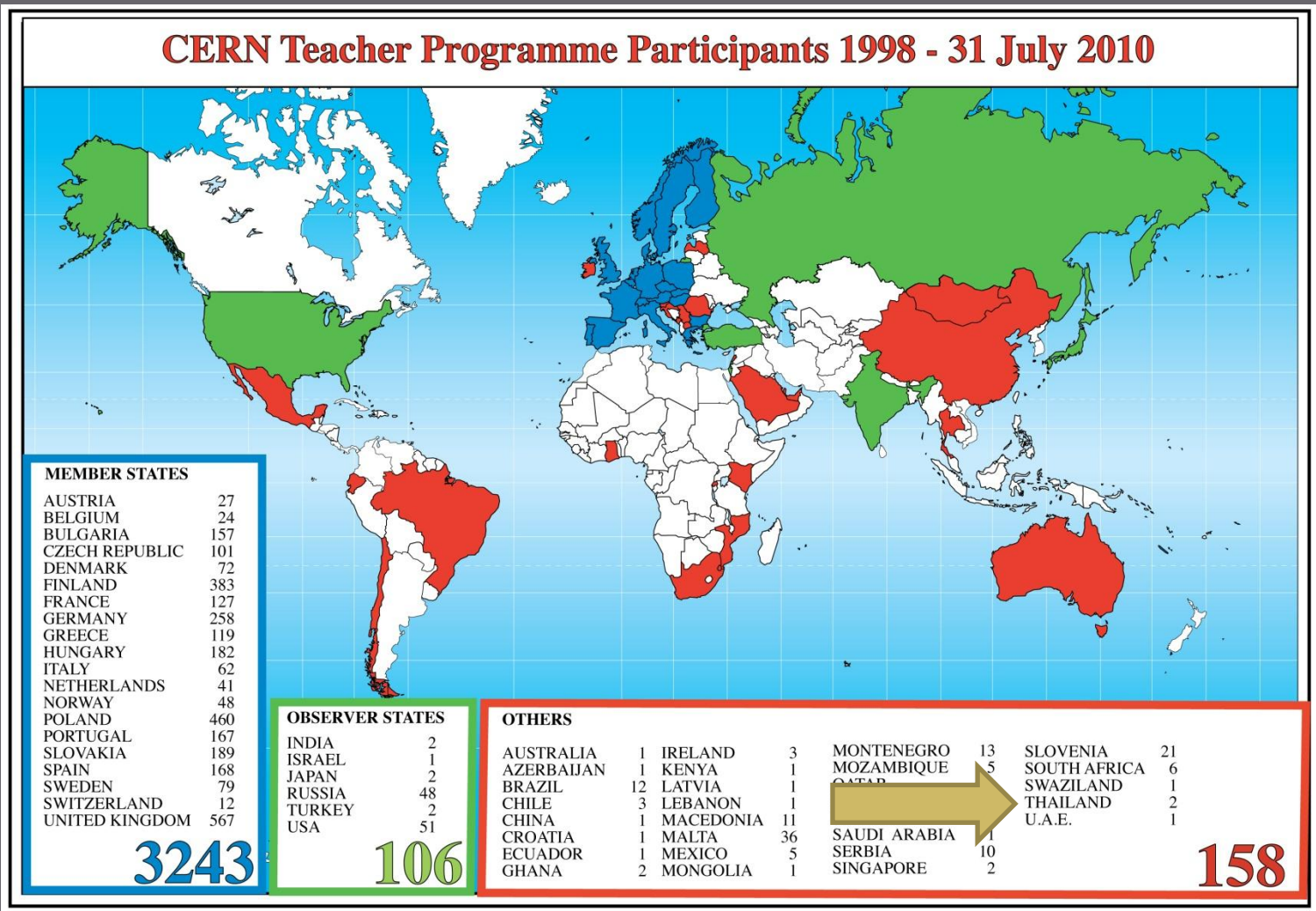
Scientists at CERN
Academic Training Programme

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

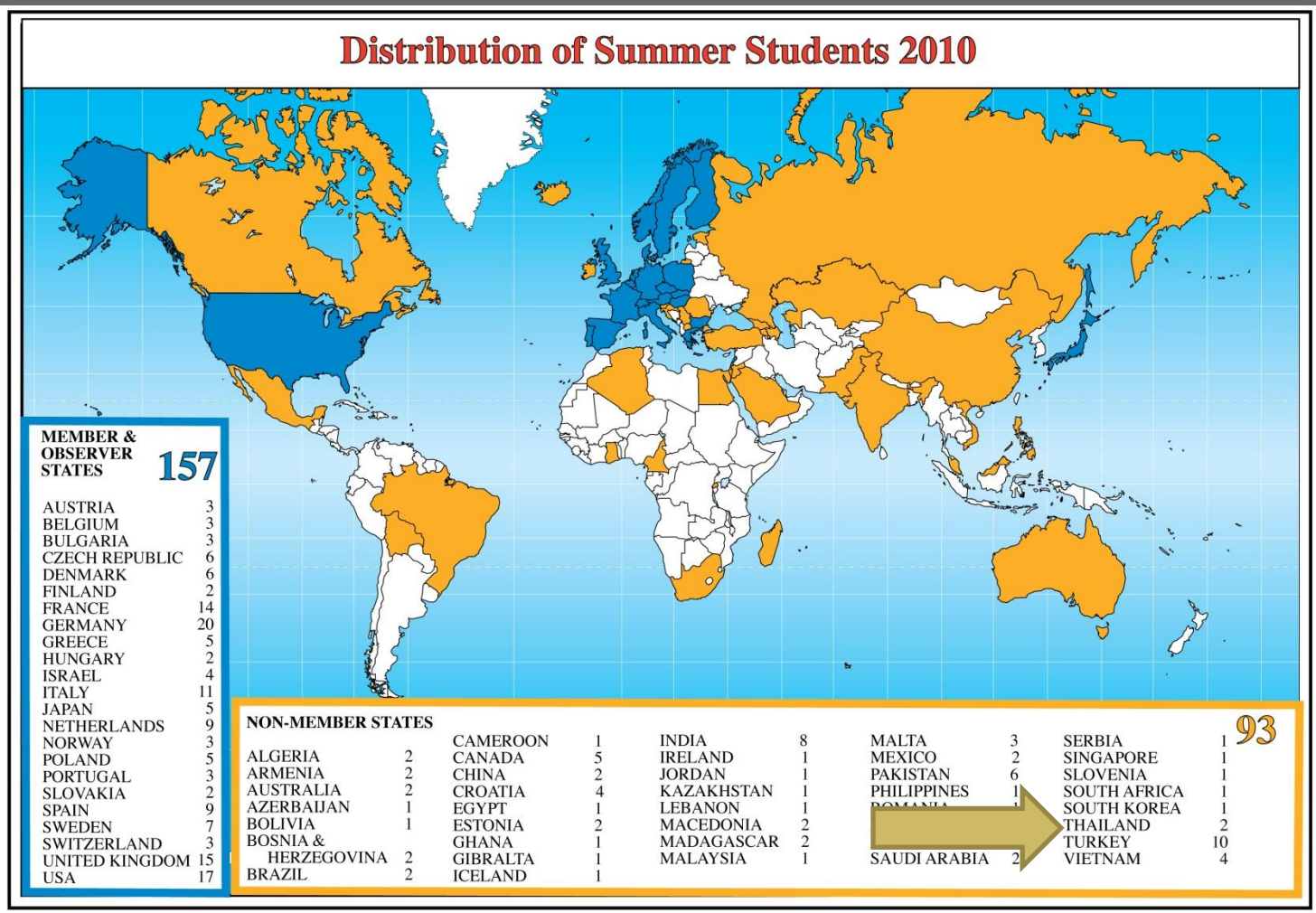
Physics Students
Summer Students
Programme

CERN Teacher Schools
International and National
Programmes

High School Teachers @ CERN



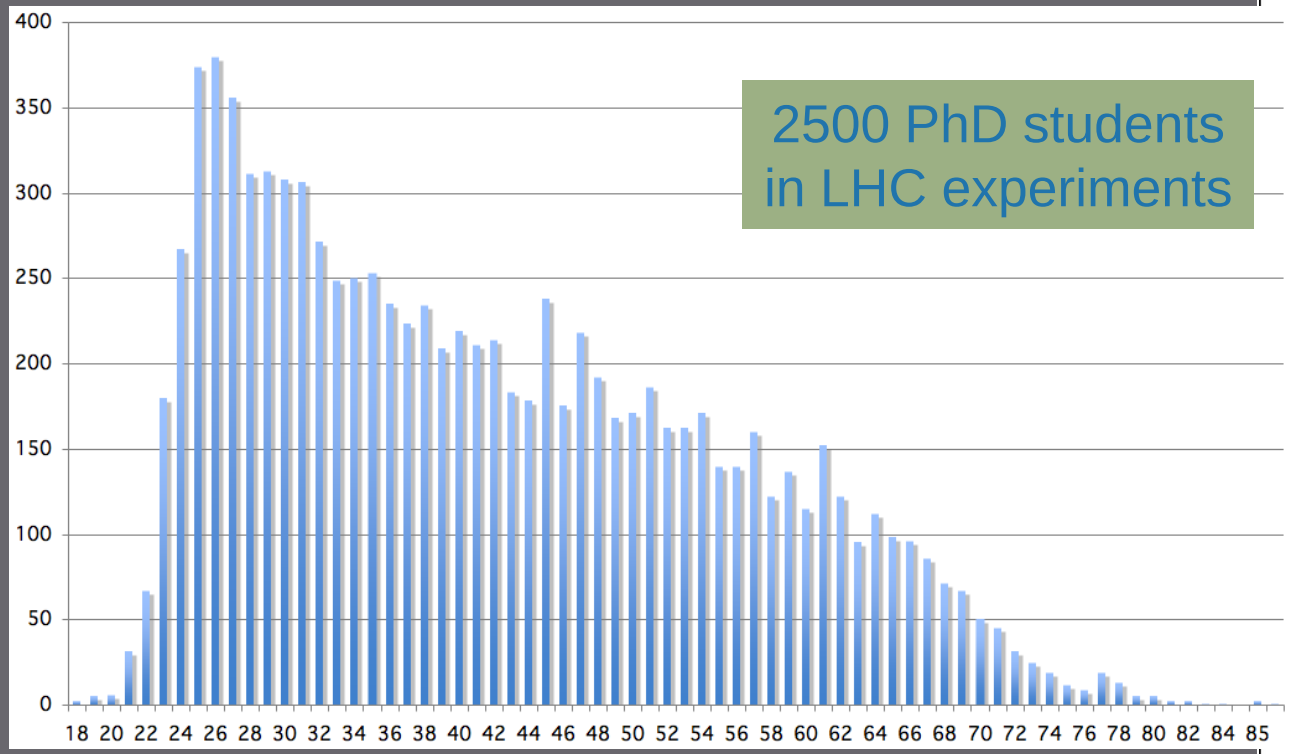
Summer Students @ CERN



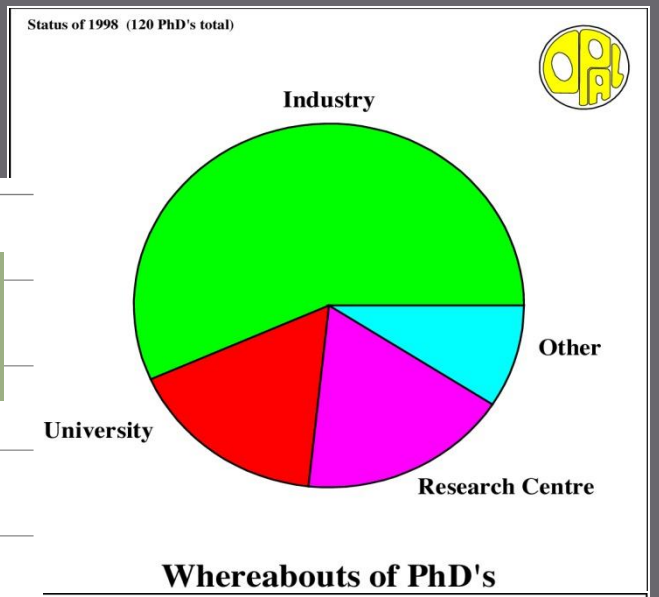
Age Distribution of Scientists

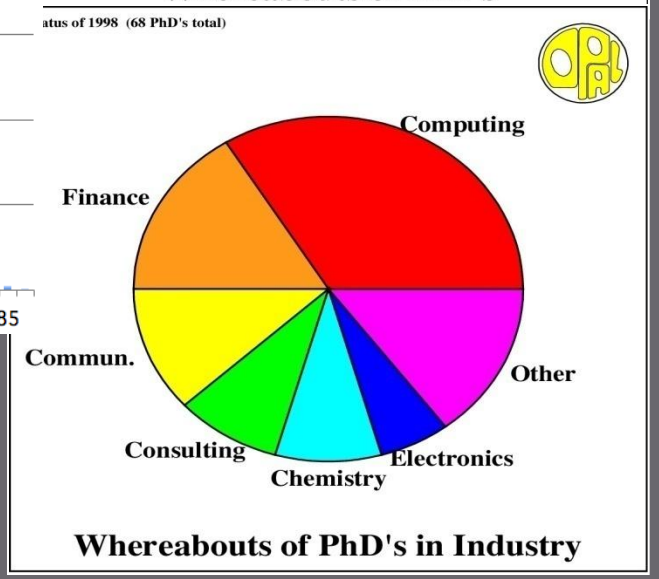
- and where they go afterwards

Survey in March 2009



2500 PhD students in LHC experiments





They do not all stay: where do they go?

Summary and Conclusions

- With the LHC, the world particle physics community has the opportunity to address fundamental questions such as What is the origin of the mass of particles? and What is the nature of dark matter?
- The LHC is the most powerful instrument ever built to investigate properties of particles and the physics results from the LHC will determine the future course of high energy physics.

Particle Physics can and should play its role as

spearhead in fundamental research & innovations as in the past

now and in future


Thank You !