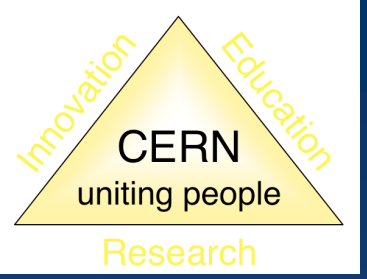
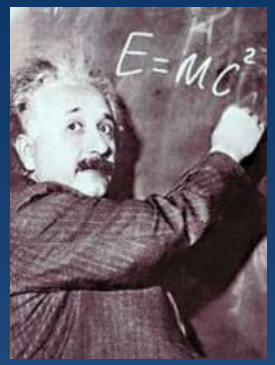
Welcome
CERN
to
Accelerating Science and Innovation

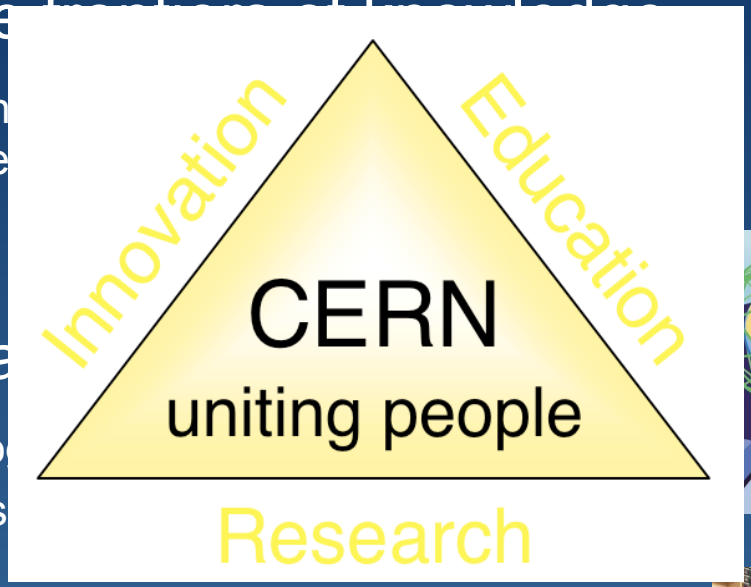


The Mission of CERN



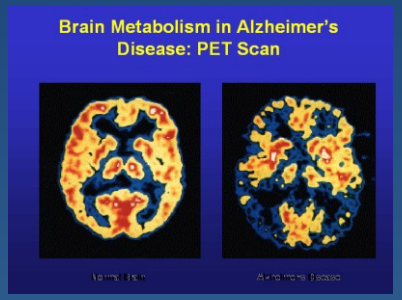
- Push back the

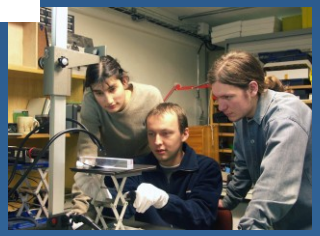
  E.g. the secrets of th
  within the first mome



- Develop new
  accelerators a

  Information technolo
  Medicine - diagnosis





- Train scientists and engineers of tomorrow

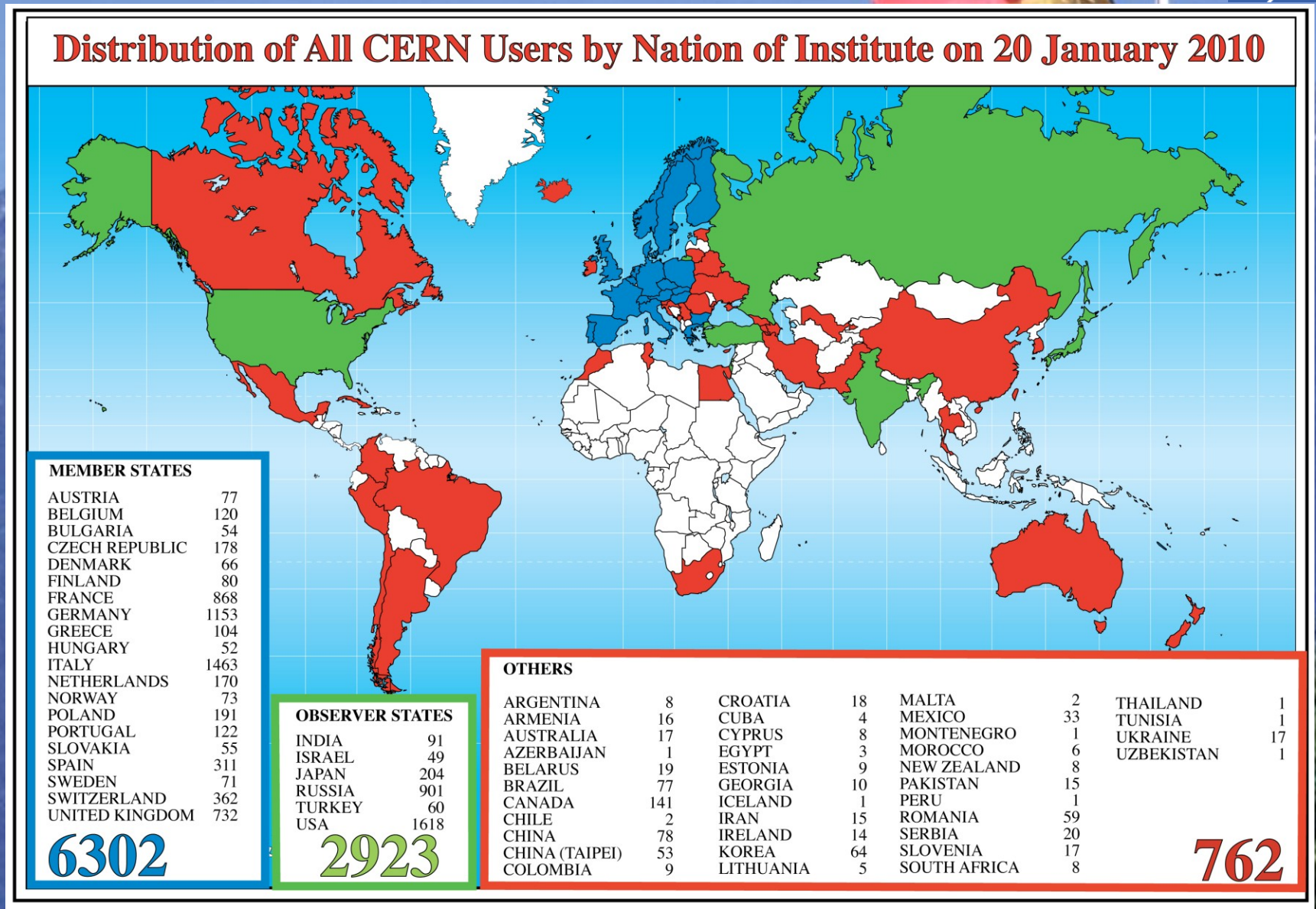
- Unite people from different countries and cultures

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

- ~ 2300 staff
- ~ 790 other paid personnel
- > 10000 users
- Budget (2010): ~1200 MCHF

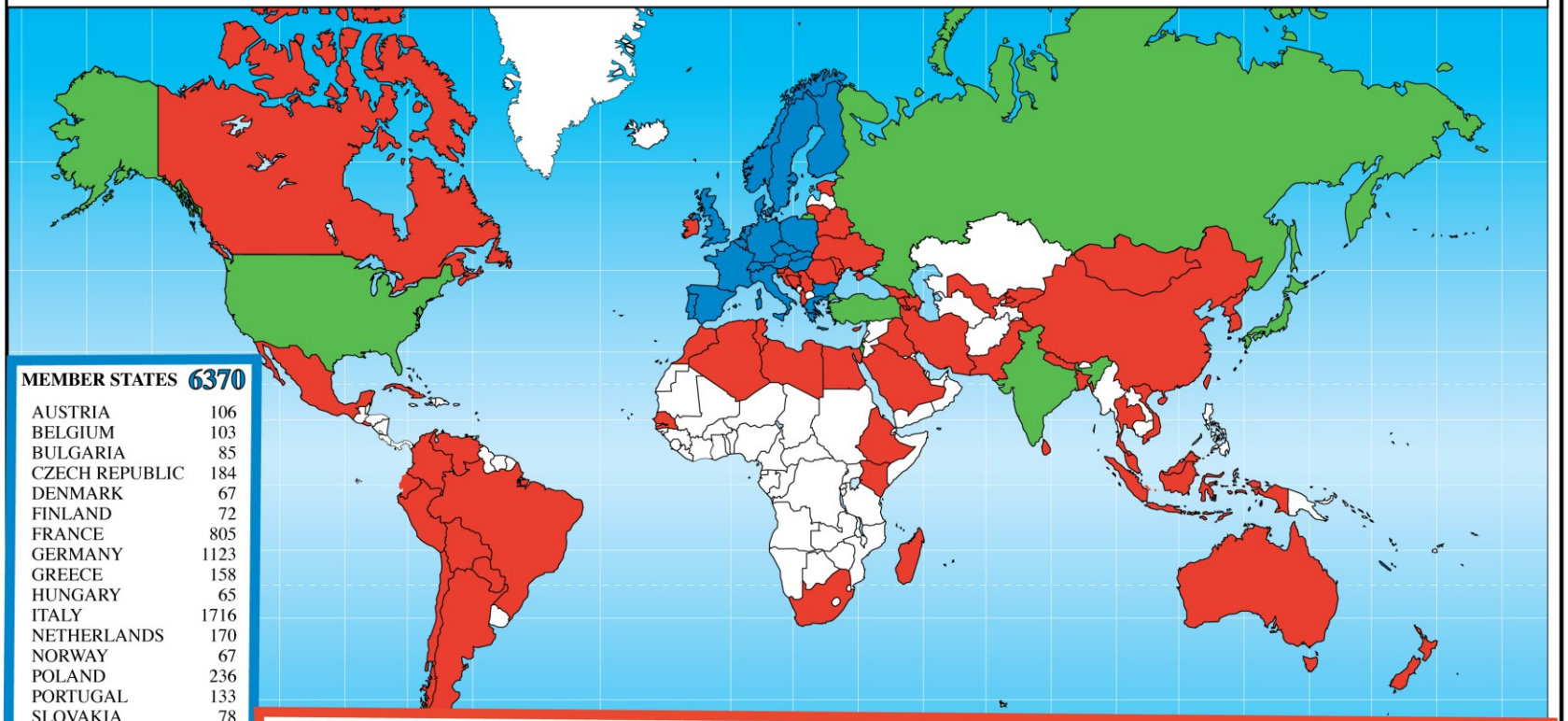
- 20 Member States: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.
- 1 Candidate for Accession to Membership of CERN: Romania
- 8 Observers to Council: India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO

CERN in Numbers



CERN in Numbers

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

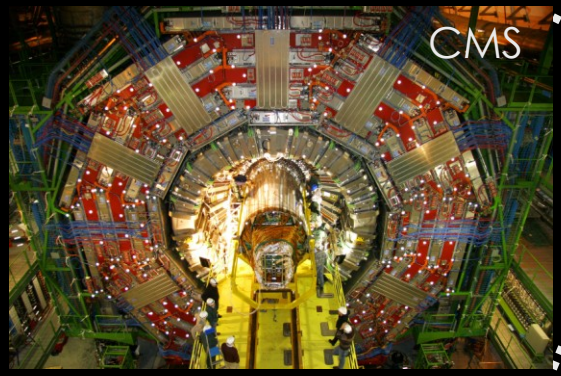
INDIA	158
ISRAEL	51
JAPAN	229
RUSSIA	1027
TURKEY	87
USA	892

OTHERS 1205

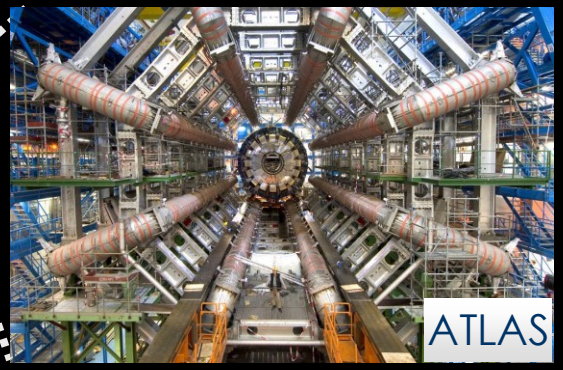
ALBANIA	2	BRAZIL	79	ESTONIA	9	KYRGYZSTAN	1	MOROCCO	16	SINGAPORE	1
ALGERIA	8	CANADA	136	ETHIOPIA	1	LEBANON	8	NEPAL	3	SLOVENIA	20
ARGENTINA	11	CHILE	3	GEORGIA	31	LITHUANIA	9	NEW ZEALAND	10	SOUTH AFRICA	9
ARMENIA	24	CHINA	202	GIBRALTAR	1	LUXEMBOURG	5	PAKISTAN	33	SRI LANKA	6
AUSTRALIA	20	CHINA (TAIPEI)	41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

Enter a New Era in Fundamental Science

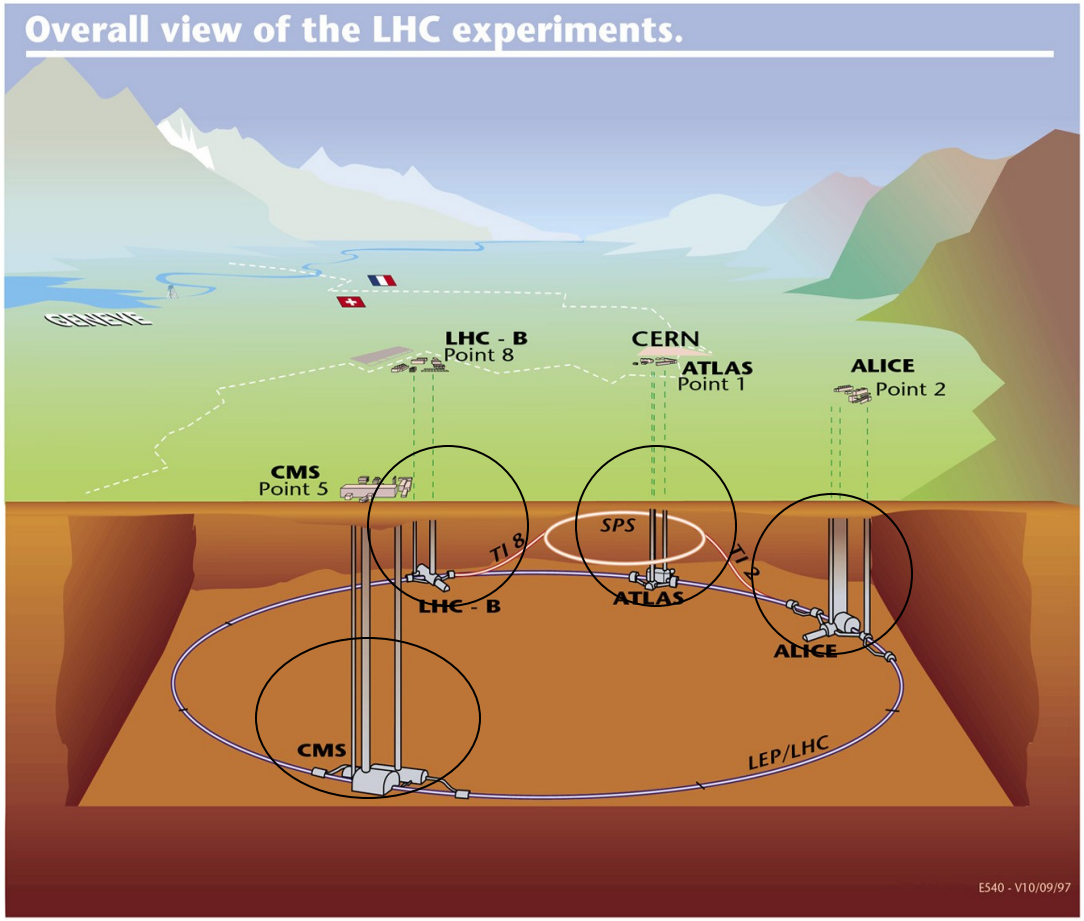
Start-up of the Large Hadron Collider (LHC), one of the largest and truly global scientific projects ever, is the most exciting turning point in particle physics.



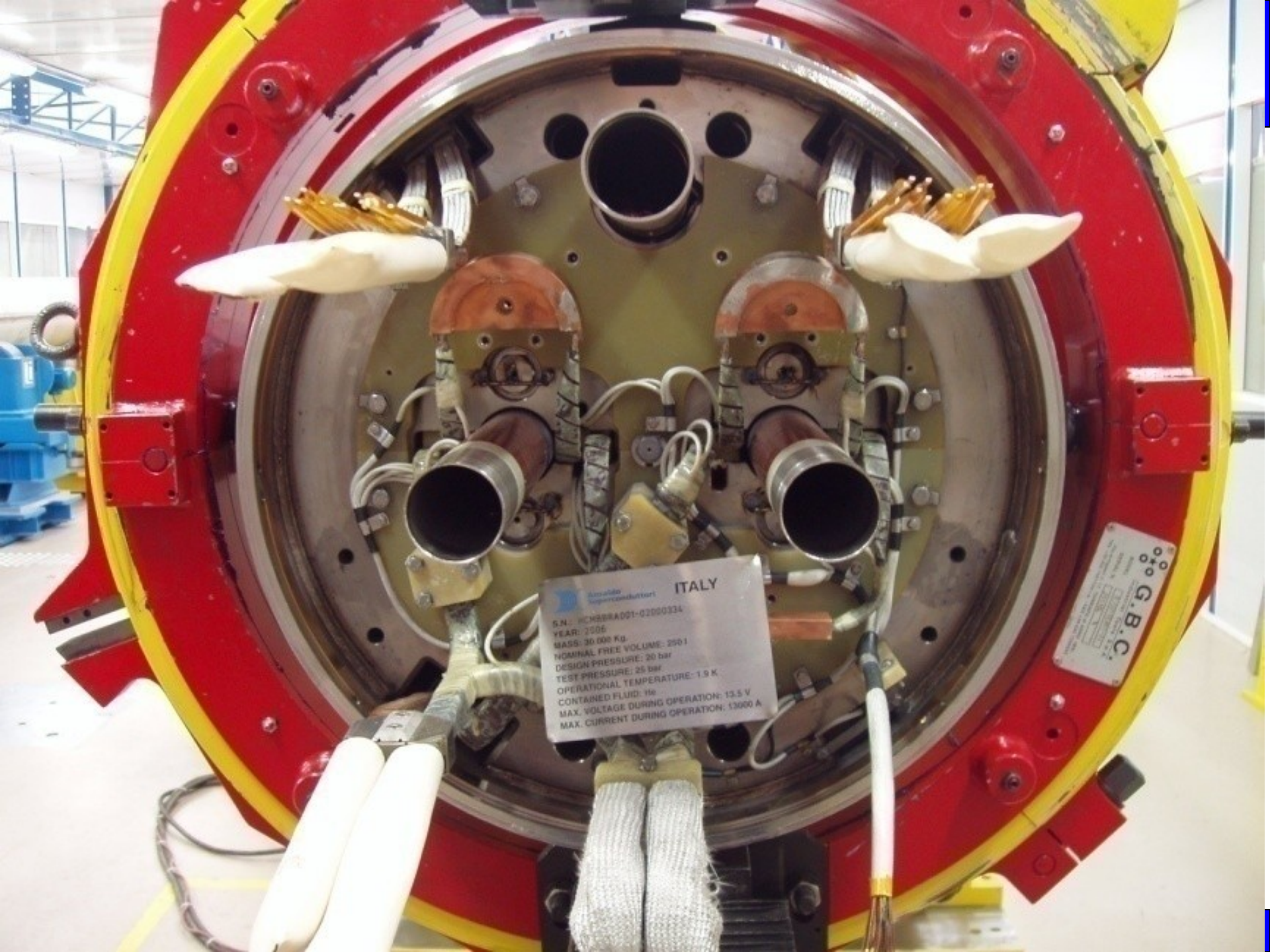
Exploration of a new energy frontier
Proton-proton collisions at E_{CM} = 14 TeV



The Large Hadron Collider (LHC) will be the most powerful instrument ever built to investigate particles properties.



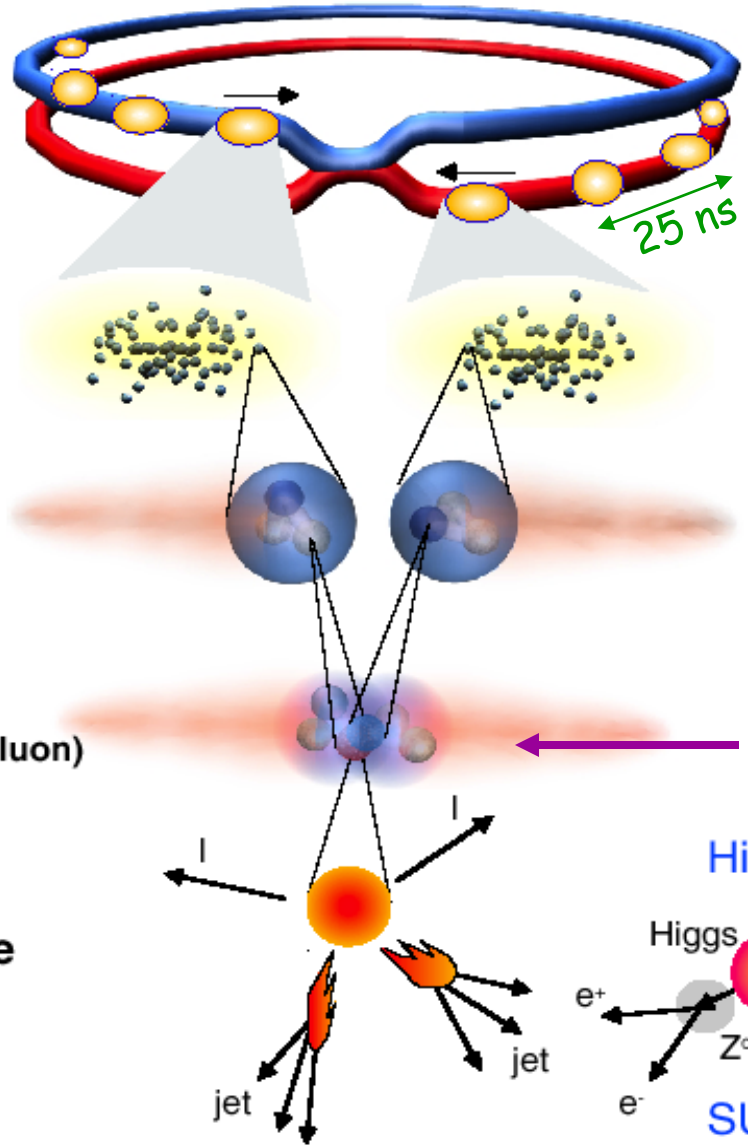
- Four gigantic underground caverns to host the huge detectors
- The highest energy of any accelerator in the world
- The most intense beams of colliding particles
- It will operate at a temperature colder than outer space


ITALY
S.N.: HCMBBRA001-02000334
YEAR: 2006
MASS: 30.000 Kg
NOMINAL FREE VOLUME: 250 l
DESIGN PRESSURE: 20 bar
TEST PRESSURE: 25 bar
OPERATIONAL TEMPERATURE: 1.9 K
CONTAINED FLUID: He
MAX. VOLTAGE DURING OPERATION: 13.5 V
MAX. CURRENT DURING OPERATION: 13000 A
G.B.C.

Magnet transport in the tunnel without a single incident

Last Repaired Magnet (SSS) going down (30/4/2009)

Collisions at LHC



Proton/Proton collisions

10^{11} protons per bunch

Event rate in detectors :

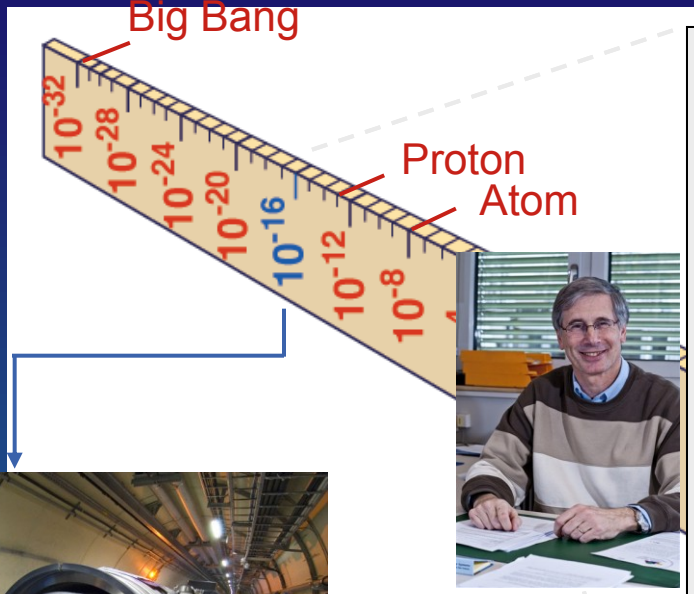
N ≈ 1,000,000,000 interactions/s

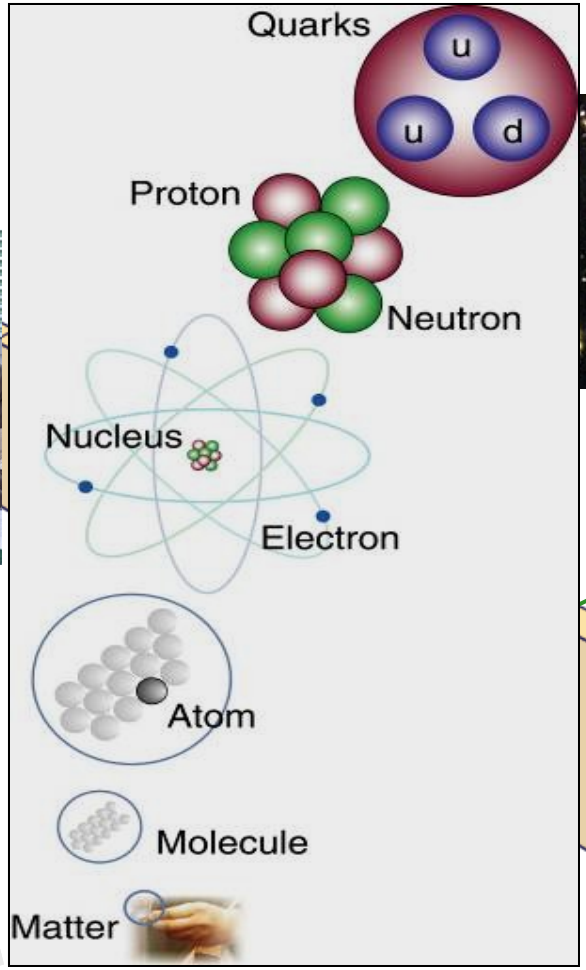
Interesting hard events are rare

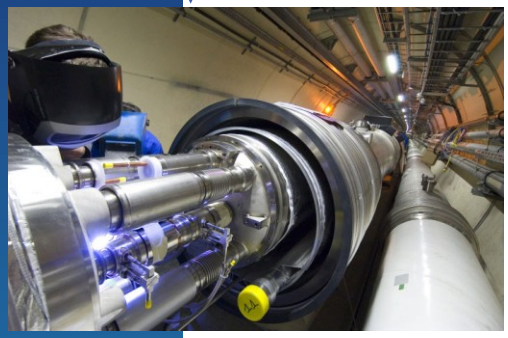
Selection of 1 in

10,000,000,000,000

→ very powerful detectors needed → → → → →

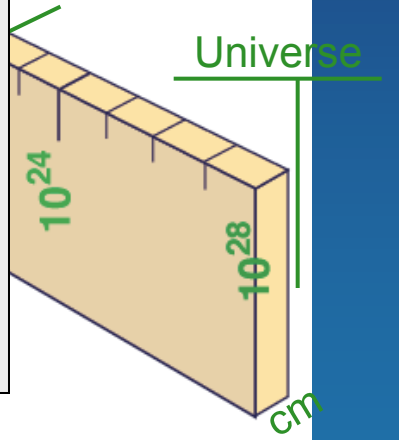






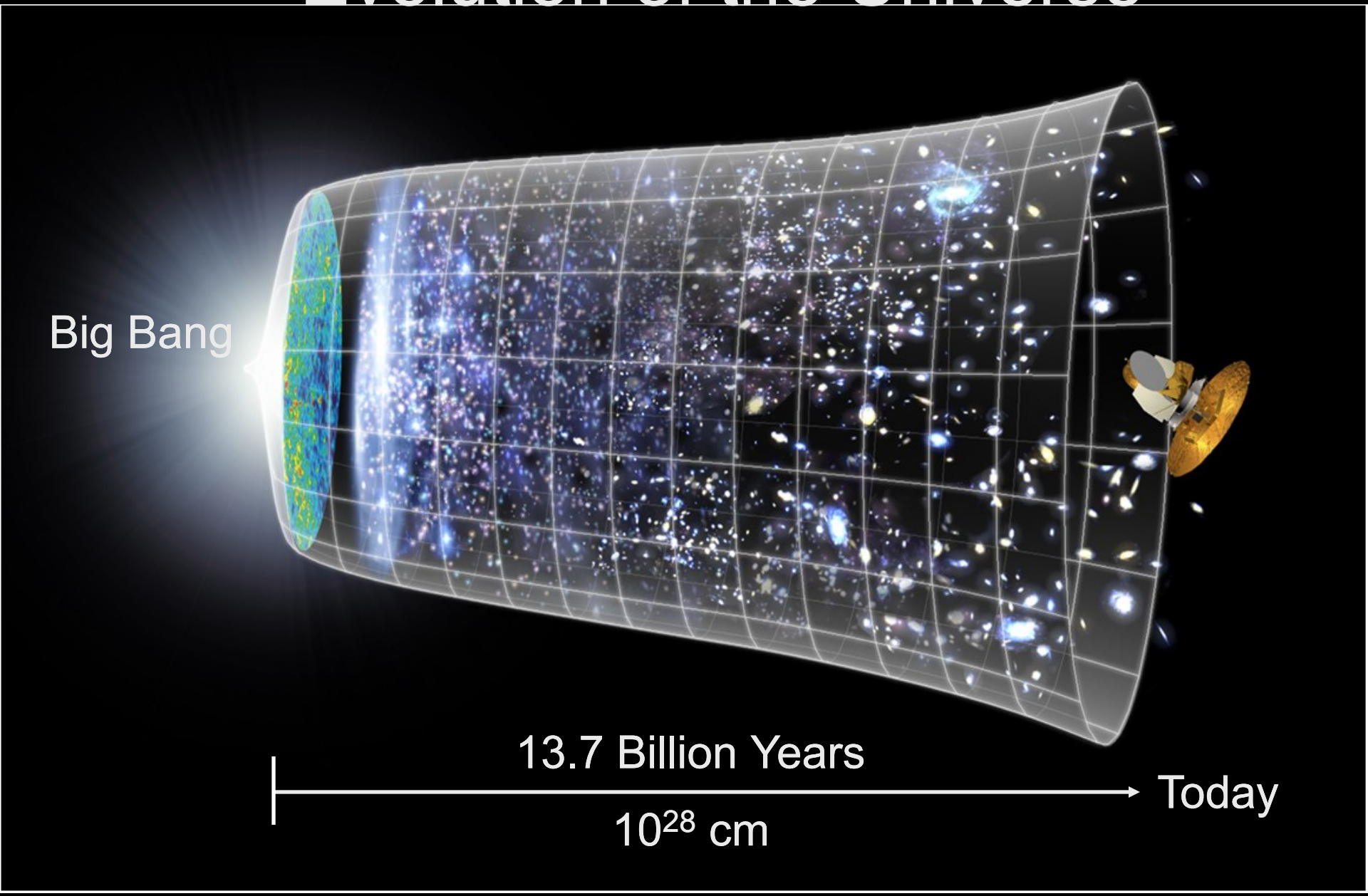
LHC

Super-Microscope

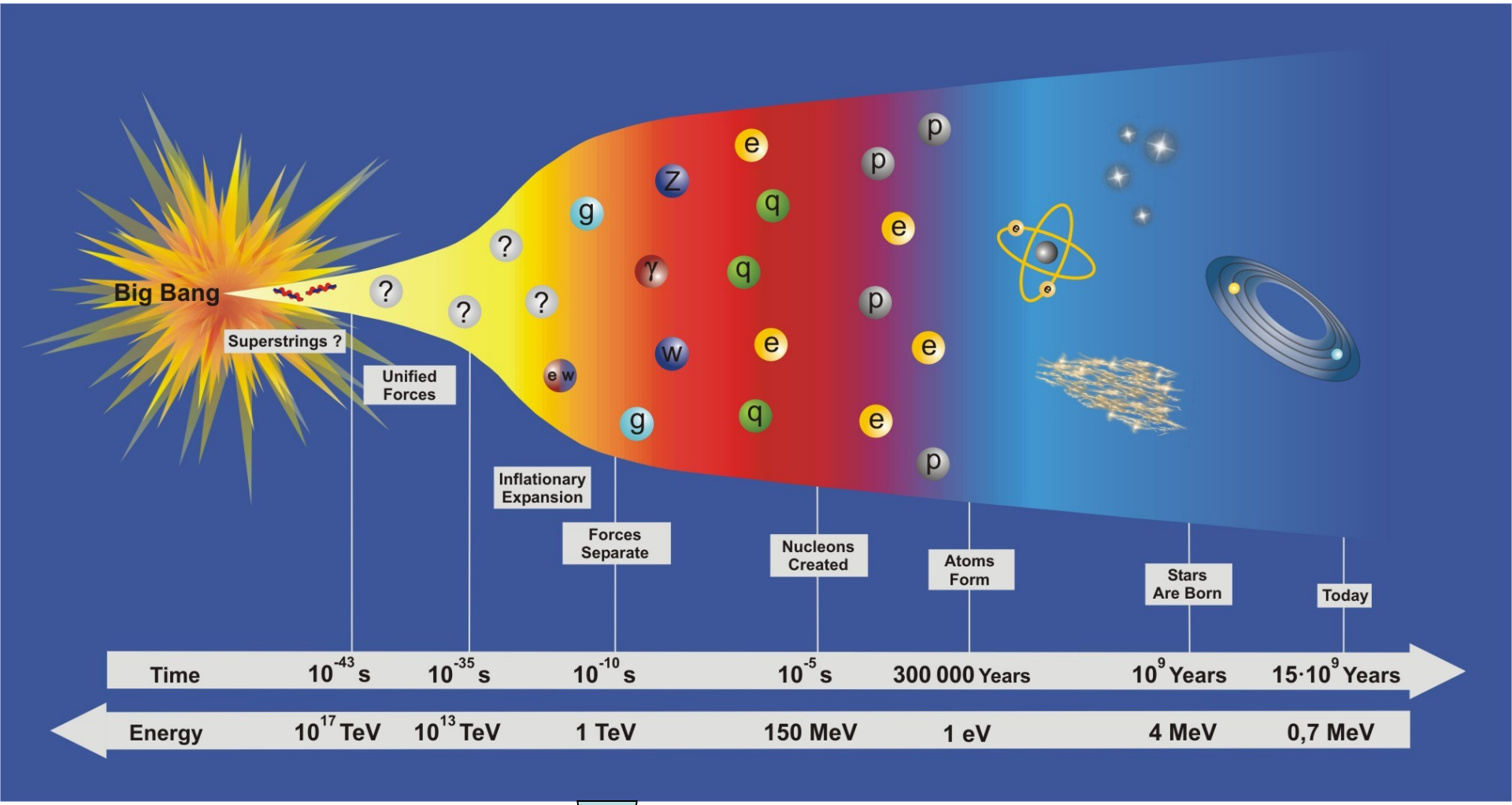


Study physics laws of first moments after Big Bang
increasing Symbiosis between Particle Physics,
Astrophysics and Cosmology

Evolution of the Universe



History of the Universe

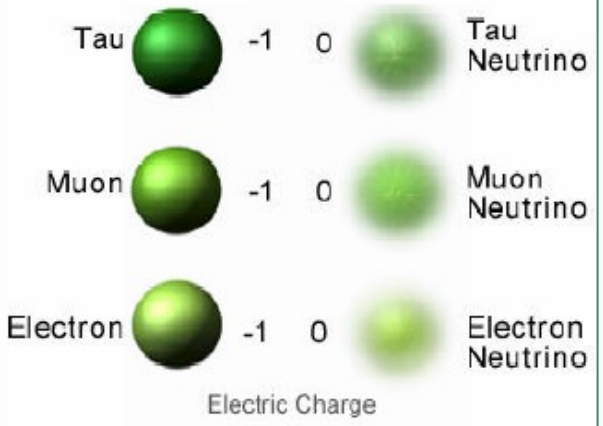


extrapolation via precision

LHC probe

Matter and forces

Leptons



Strong

Gluons (8)

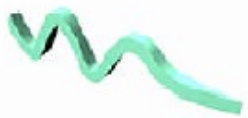
Quarks

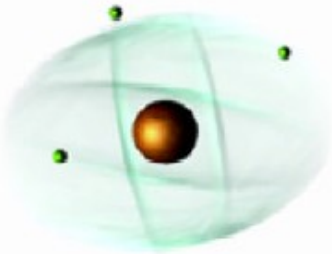
Mesons
Baryons

Nuclei

Electromagnetic

Photon





Atoms
Light
Chemistry
Electronics

Quarks

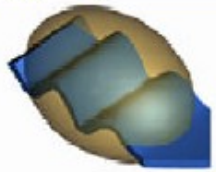
Gravitational

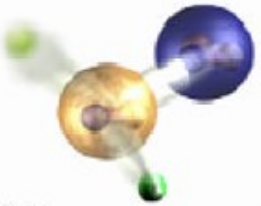
Graviton ?

Solar system
Galaxies
Black holes

Weak

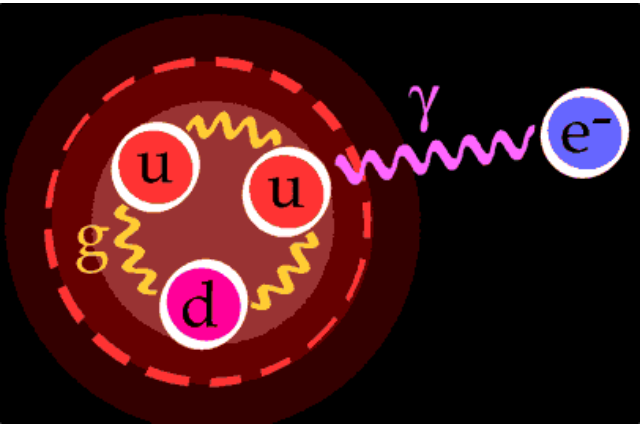
Bosons
(W,Z)



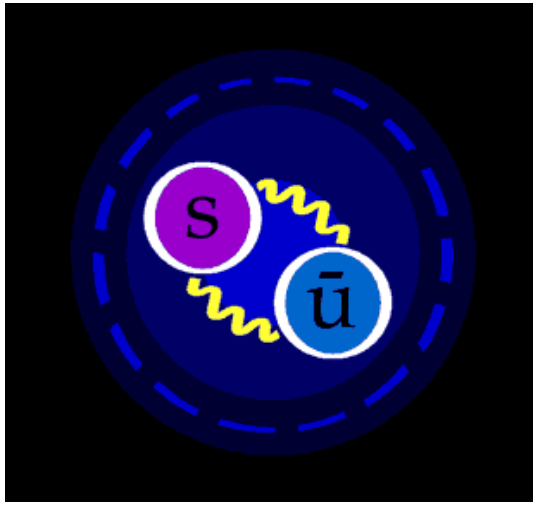


Neutron decay
Beta radioactivity
Neutrino interactions
Burning of the sun

Some particles and processes

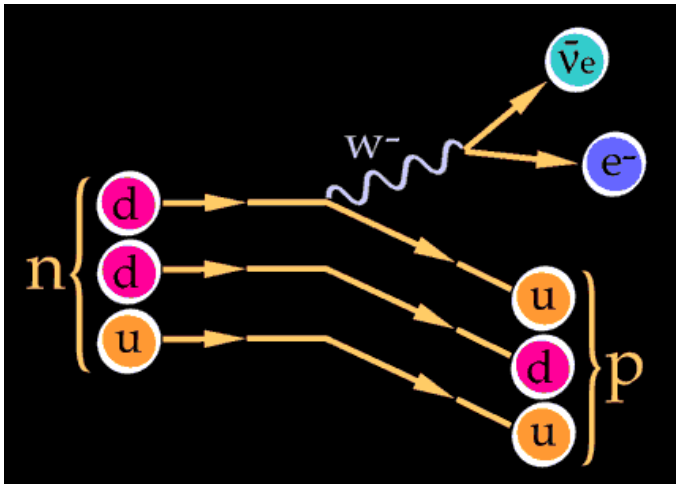


Hydrogen Atom



More exotic particle observes in accelerators

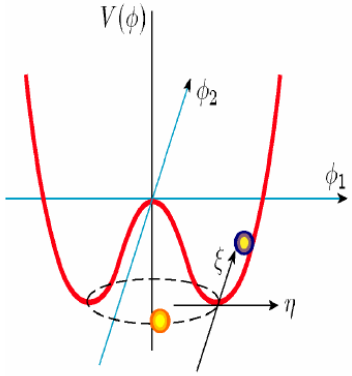
K- (kaon)

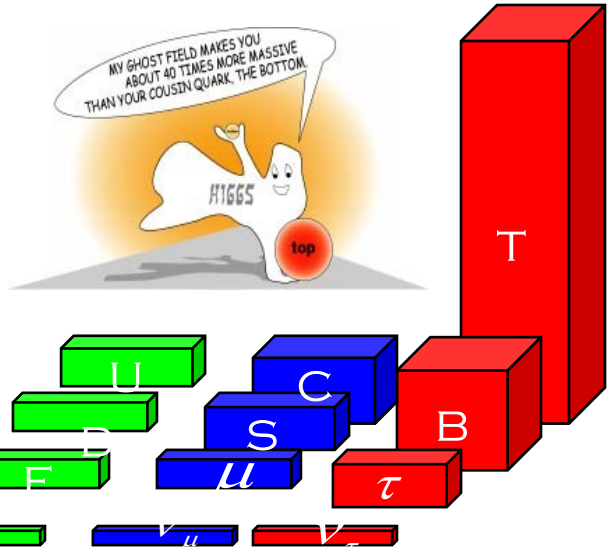


Beta decay

The Higgs Field

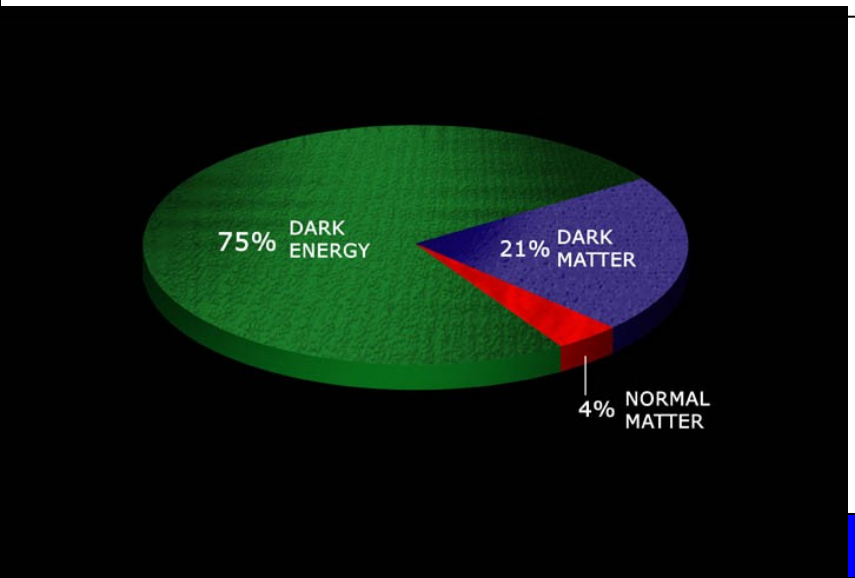
- Electroweak symmetry breaking
  - → Photon (carrier e.m. force) is massless
  - → W/Z Bosons (carrier weak force) are massive
    - LEP: M_Z = 91.1876 ± 0.0021 GeV (precision measurement!)
- Mechanism of electroweak symmetry breaking
  - → Higgs mechanism
  - → Add scalar field
  - → perform spontaneous symmetry breaking
    - Lagrangian has gauge symmetry
    - Ground state breaks symmetry
  - → keeps good properties of SM
    - Gauge invariance, renormalisability

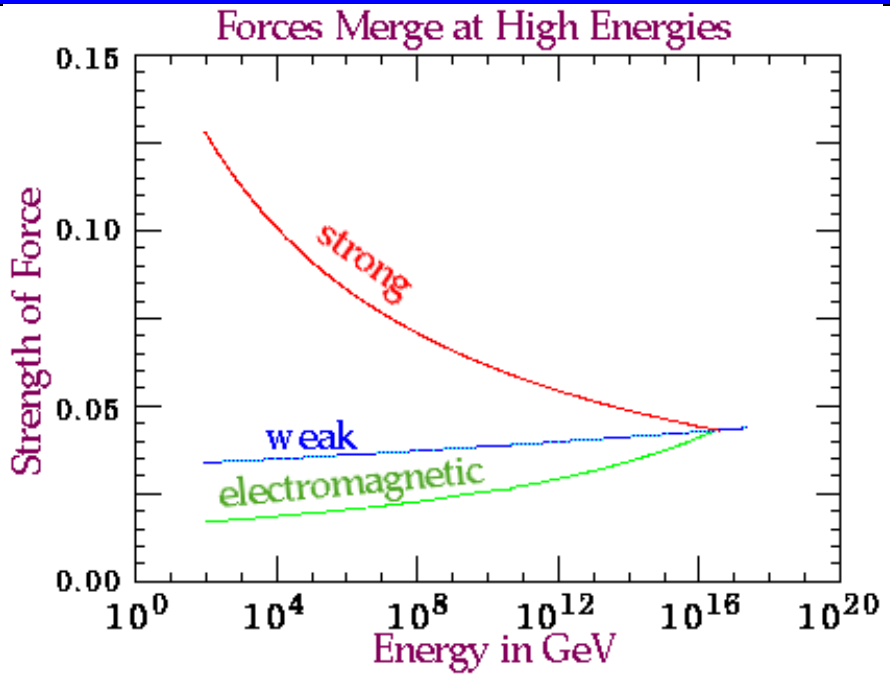


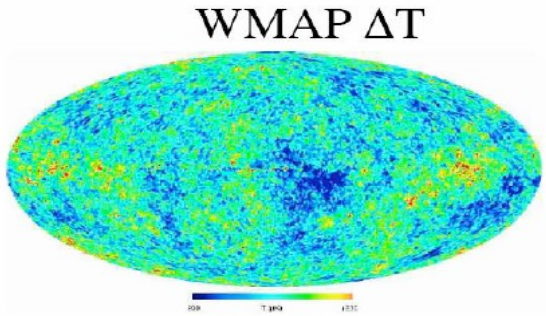


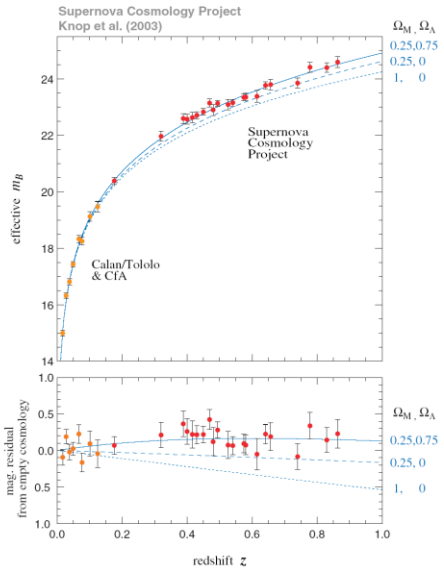
Unification of forces, dark matter

Supersymmetric particles = dark matter ?

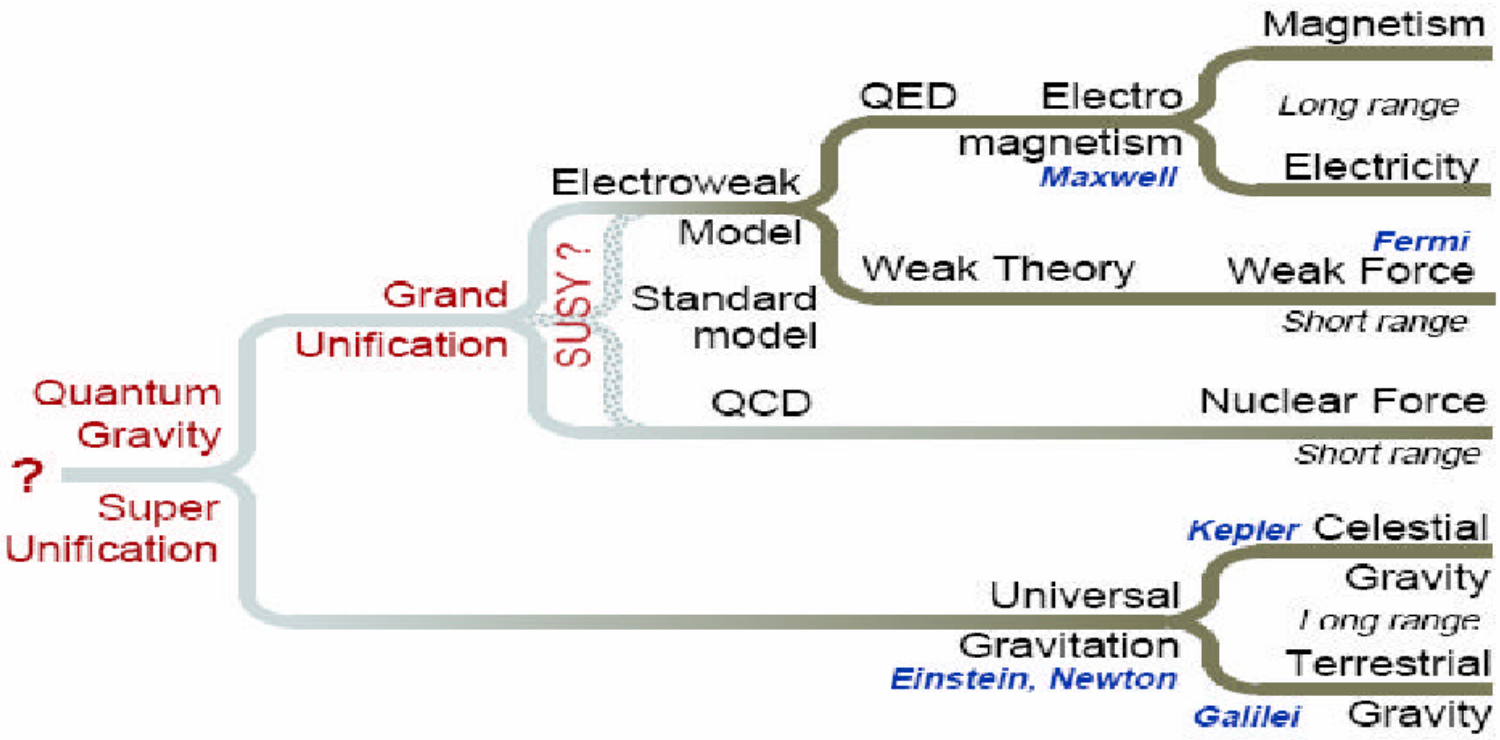




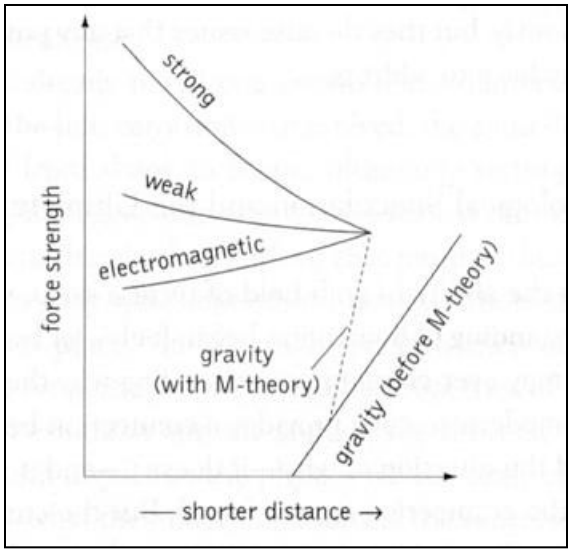


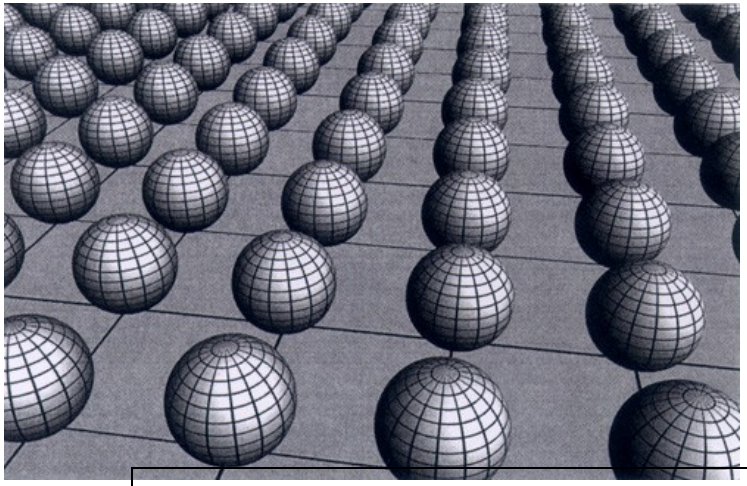


Unification of forces

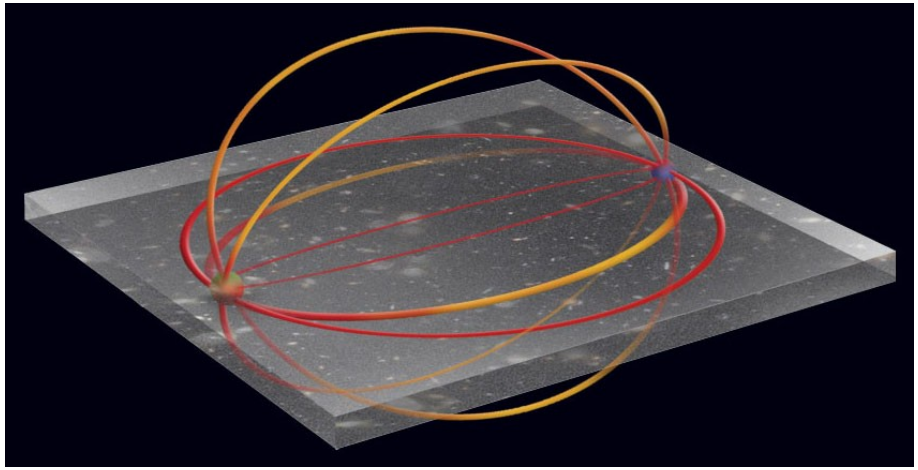


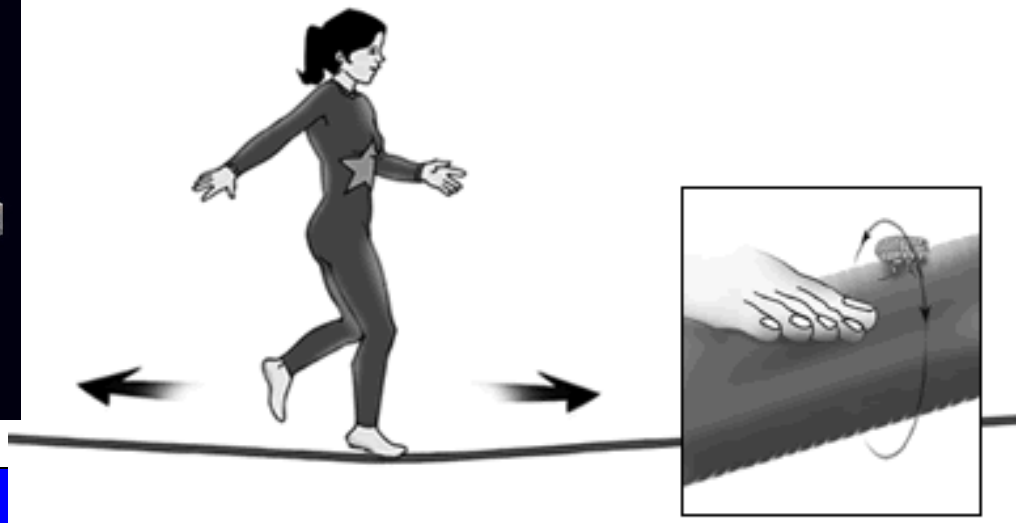
Extra dimensions



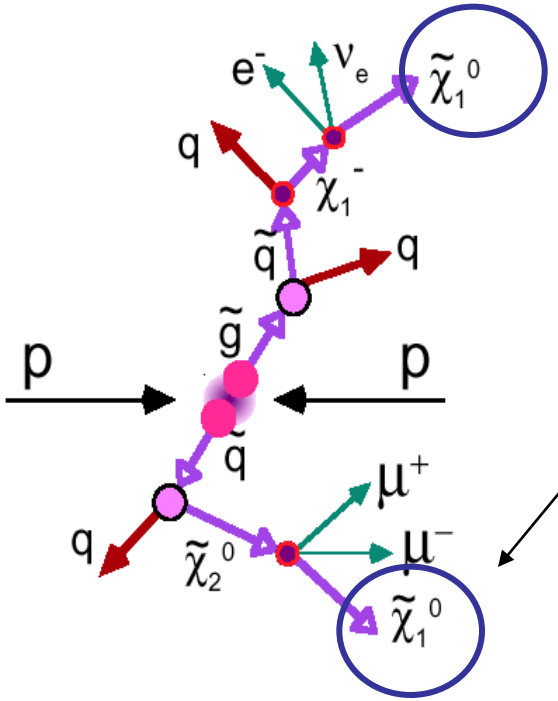


Gravitation and Quantum Mechanics





Supersymmetric particles and dark matter



This particle (neutralino) is a good candidate for the universe dark matter

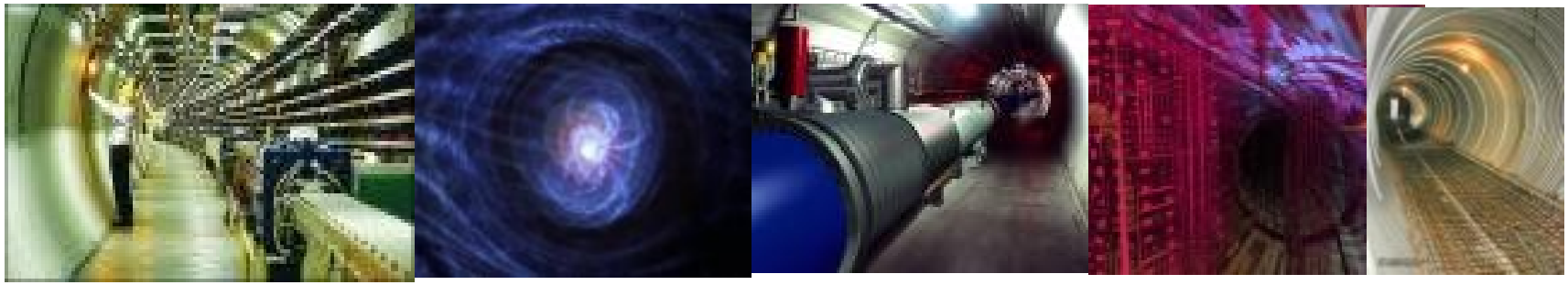
ATLAS discovery reach

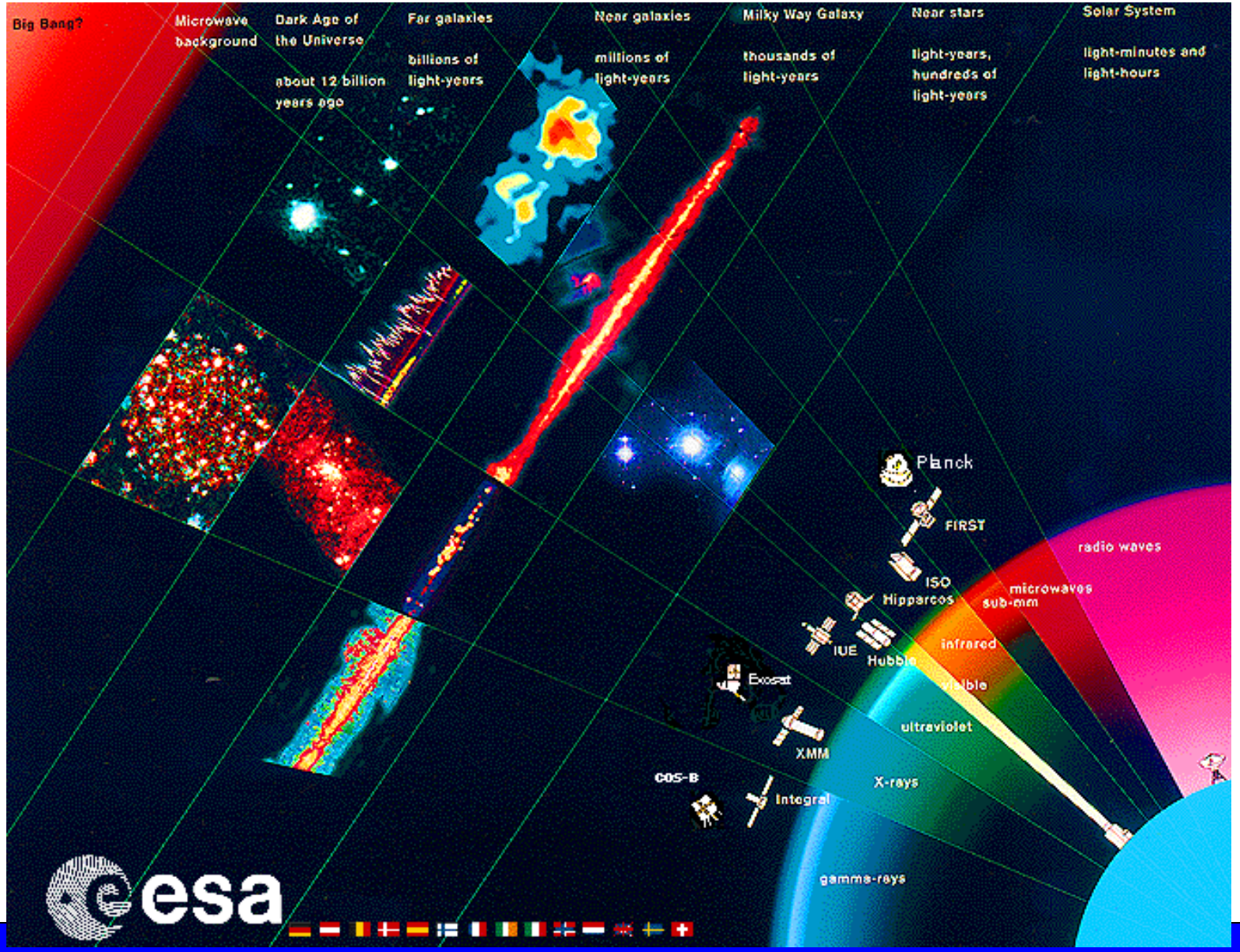
Time	reach in squark/gluino mass
1 month	~ 1.3 TeV
1 year	~ 1.8 TeV
3 years	~ 2.5 TeV
ultimate	up to ~ 3 TeV

Neutralino mass can be measured to 10% → SUSY discovery and neutralino mass measurement at LHC can solve problem of universe cold dark matter

Look outside:

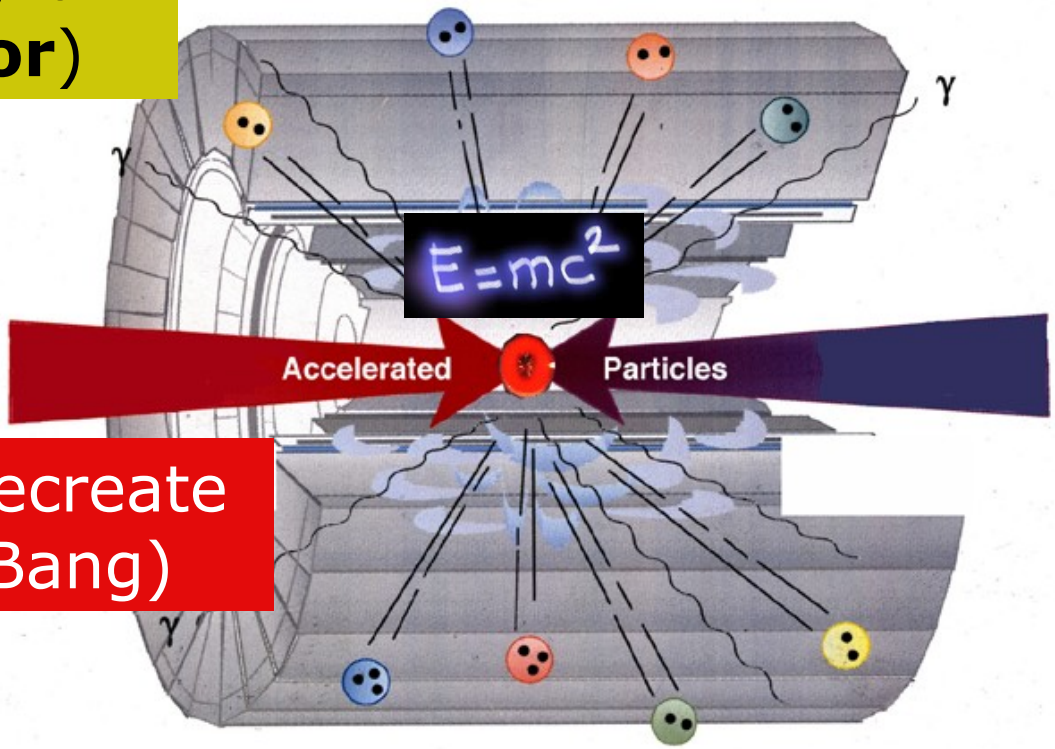
Look inside:




Big Bang?
Microwave background
Dark Age of the Universe
about 12 billion years ago
Far galaxies
billions of light-years
Near galaxies
millions of light-years
Milky Way Galaxy
thousands of light-years
Near stars
light-years, hundreds of light-years
Solar System
light-minutes and light-hours
Planck
FIRST
ISO
Hipparcos
IUE
Hubble
Exosat
XMM
COS-B
Integral
radio waves
microwaves
sub-mm
infrared
visible
ultraviolet
X-rays
gamma-rays
esa

$E = mc^2$

1) Concentrate energy on particles (**accelerator**)



2) **Collide** particles (recreate conditions after Big Bang)

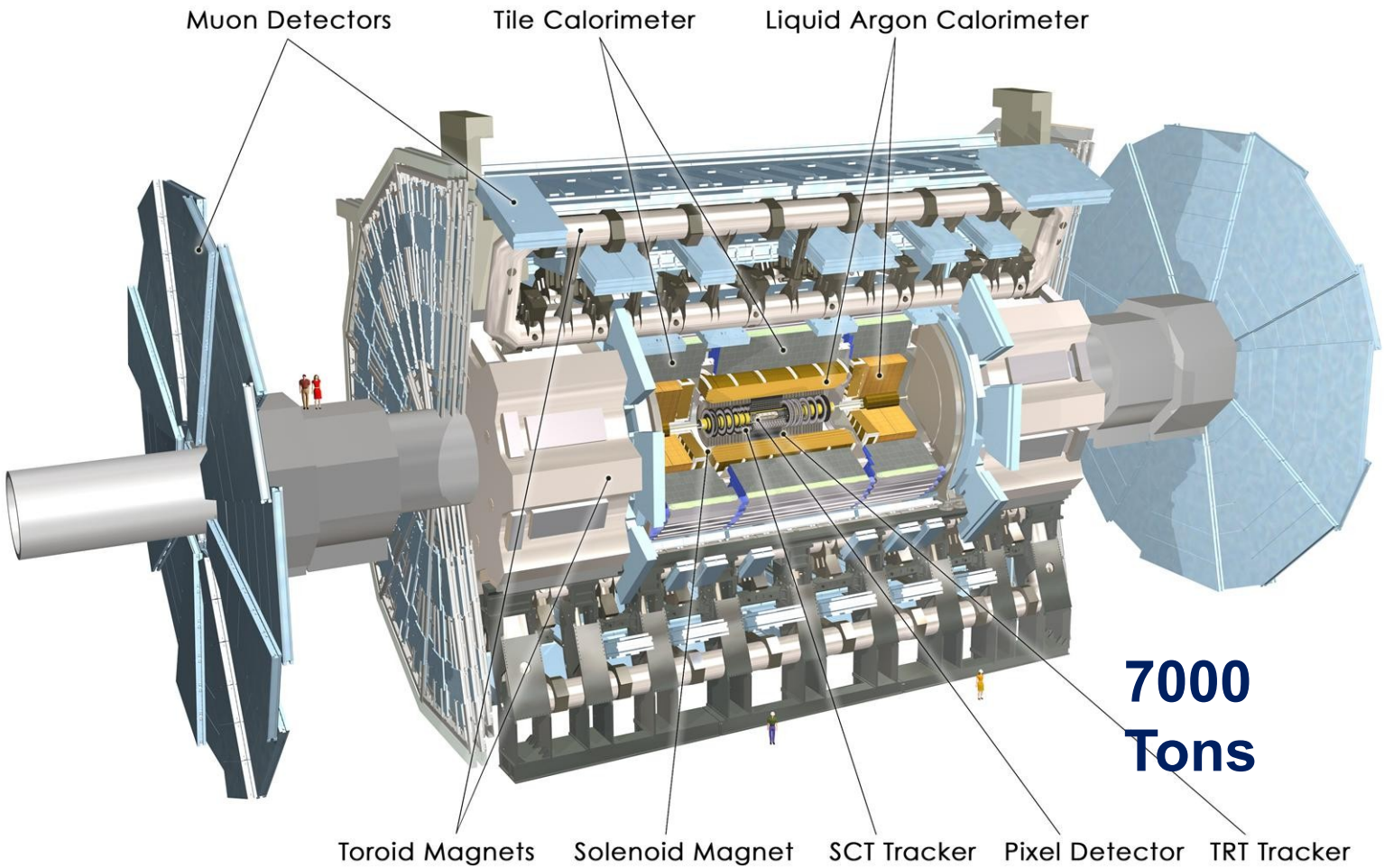
3) Identify created particles in **Detector** (search for new clues)

ATLAS Detector

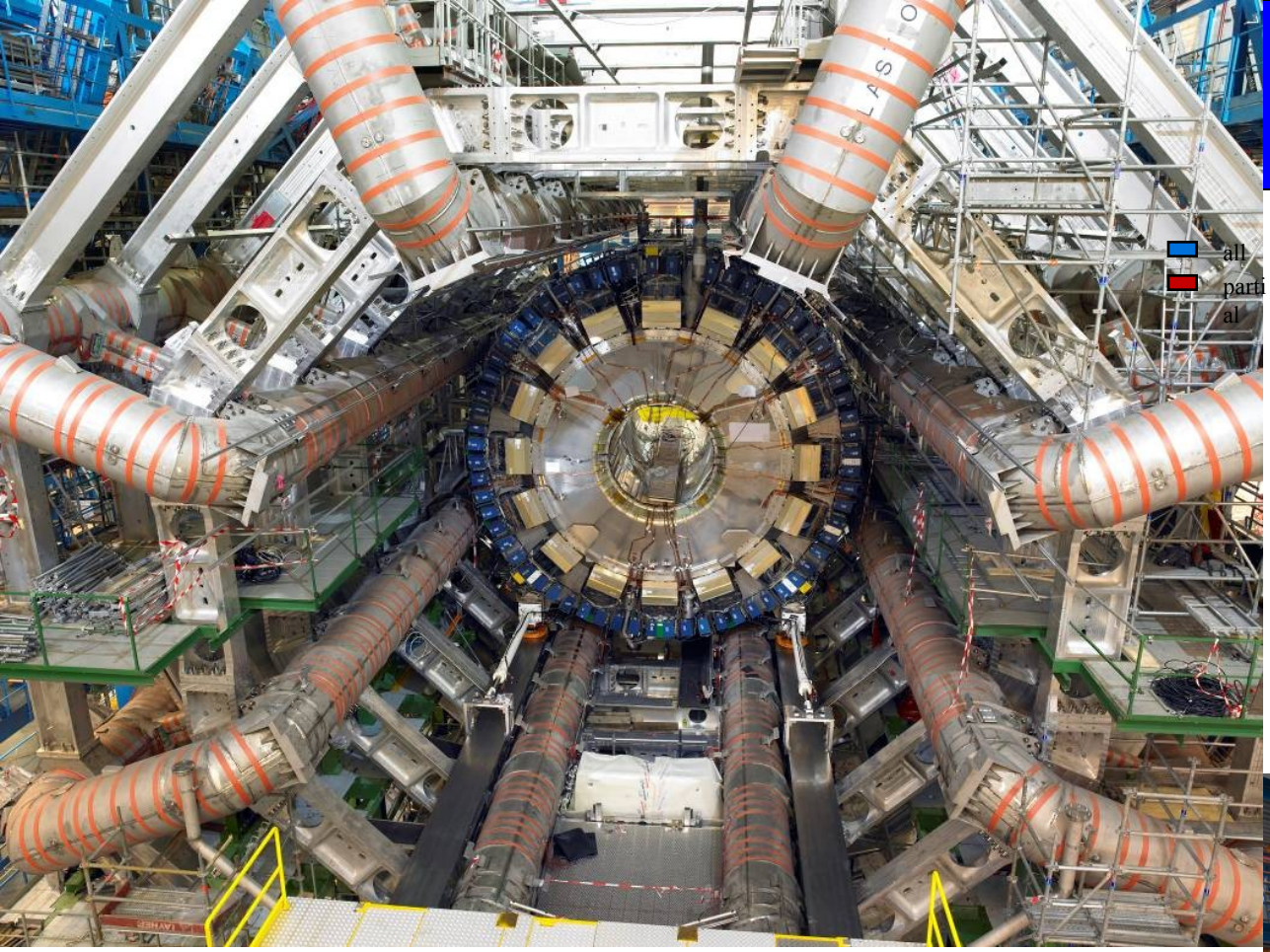
ATLAS superimposed to
the 5 floors of building 40

45 m

24 m



7000
Tons


all
parti
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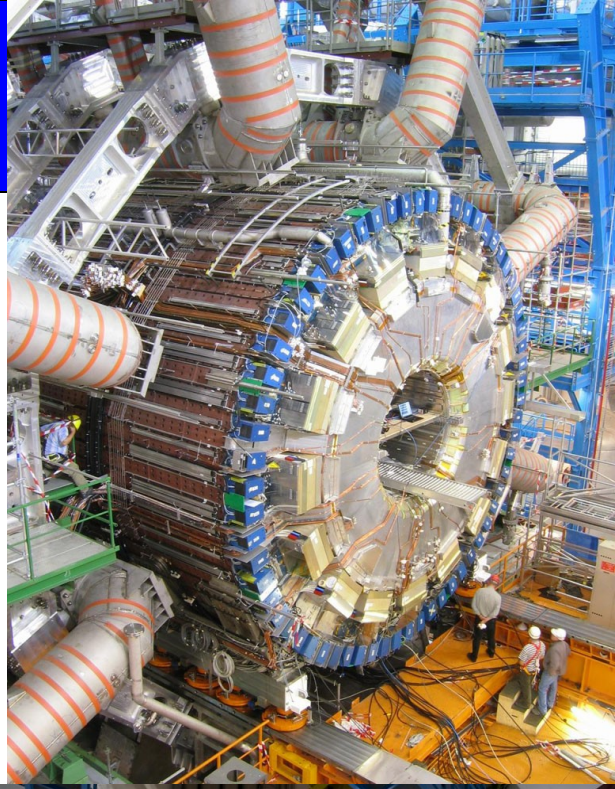
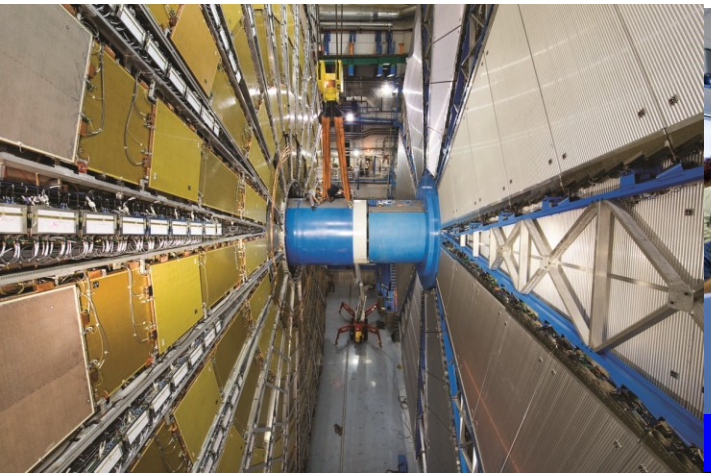
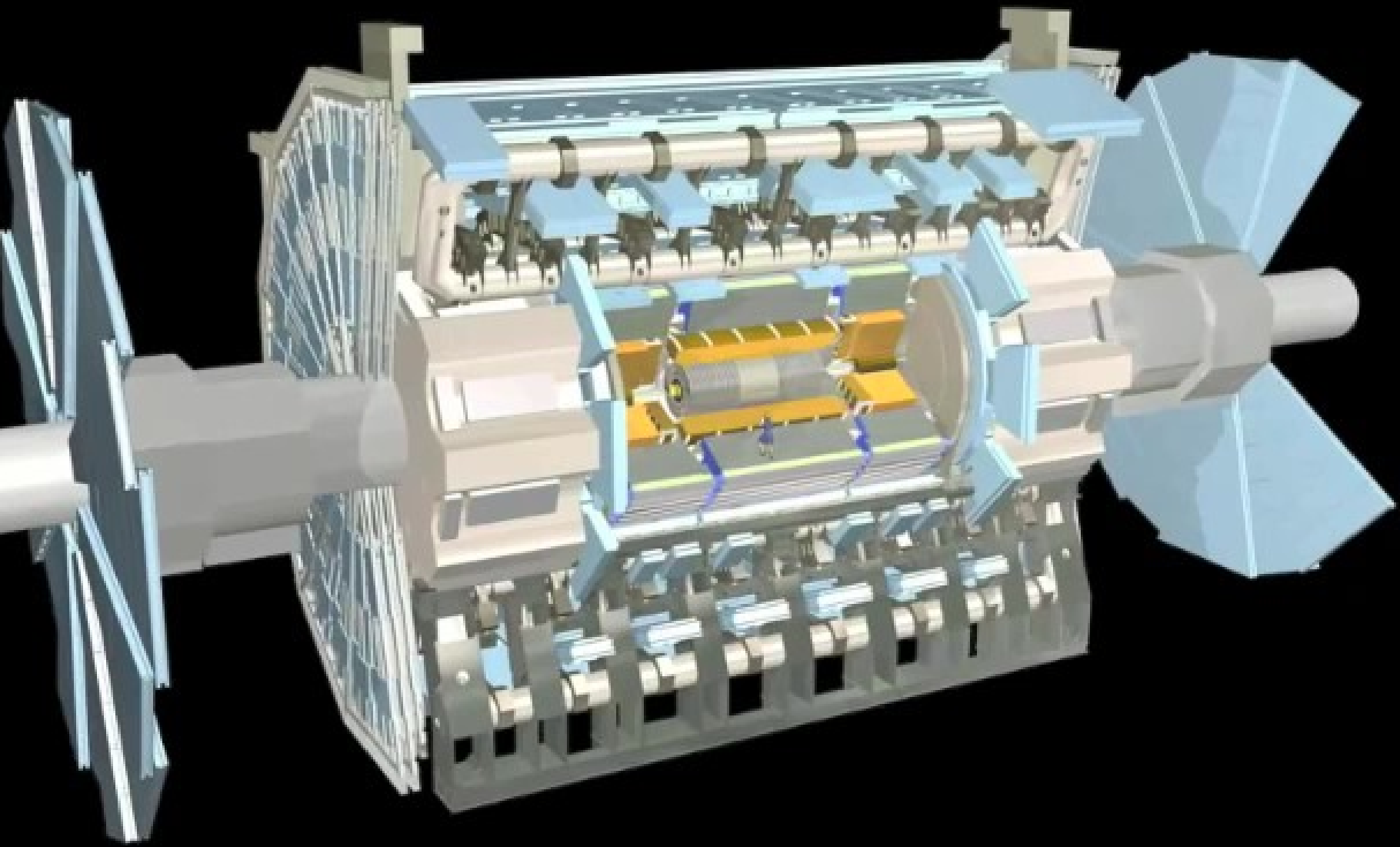




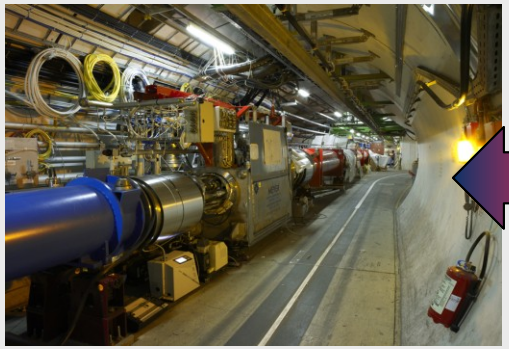


CERN Technologies - Innovation

Medical imaging

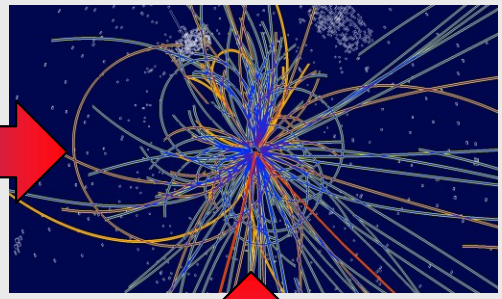
Example: medical application

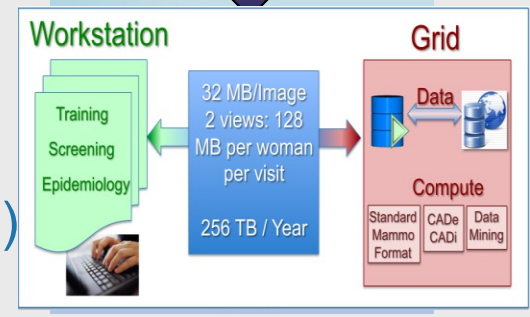
Accelerating particle beams



Charged hadron beam that loses energy in matter

Detecting particles

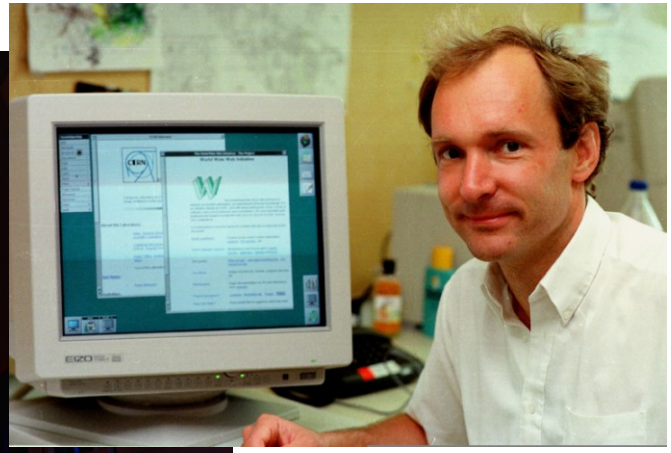


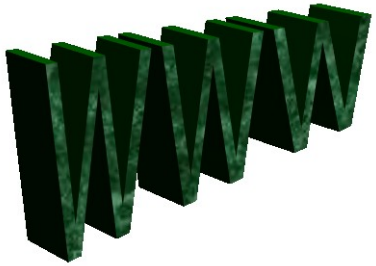


Large-scale **computing** (Grid)

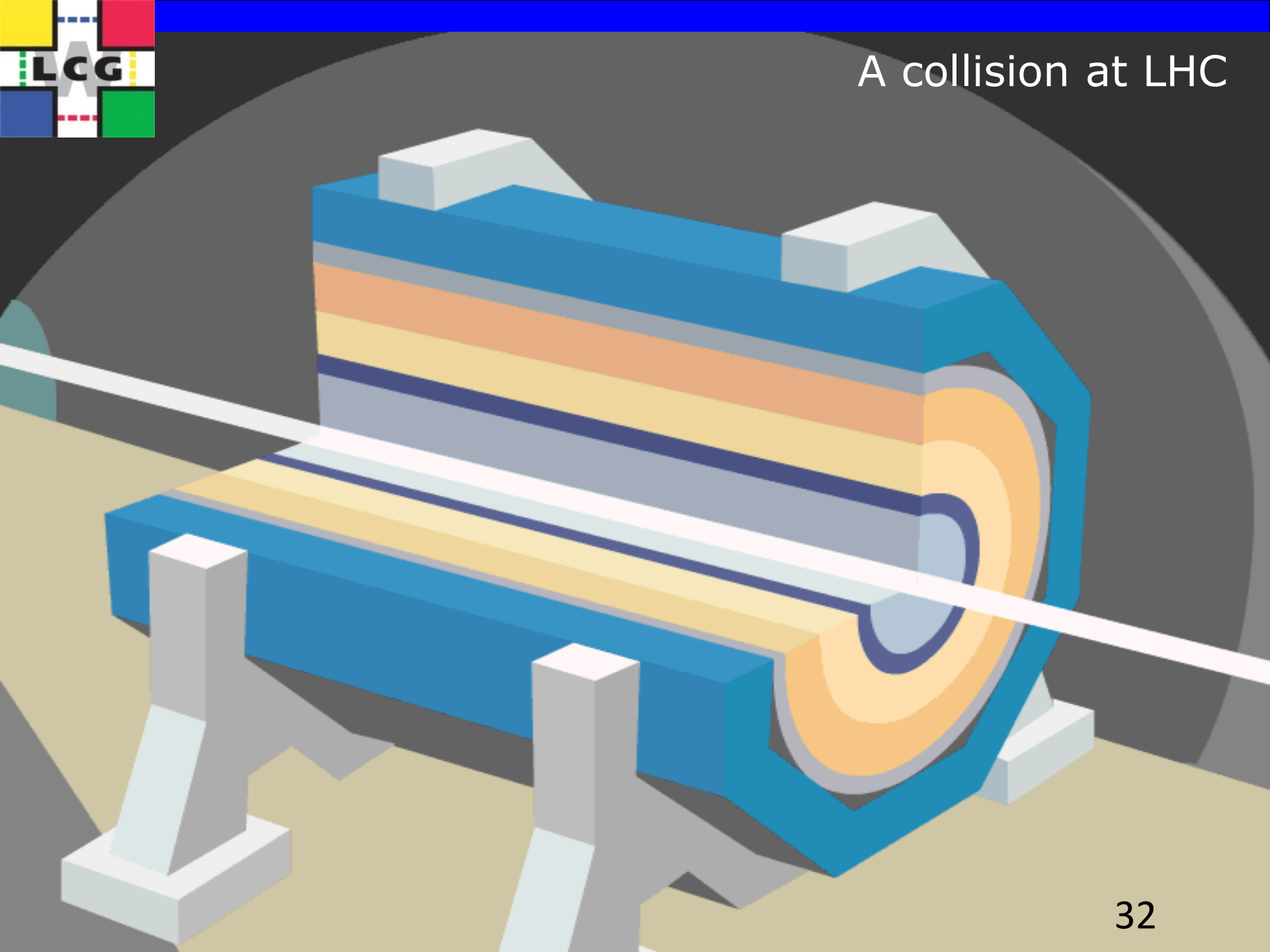
Grid computing for medical data management and analysis

CERN, Internet and the WWW

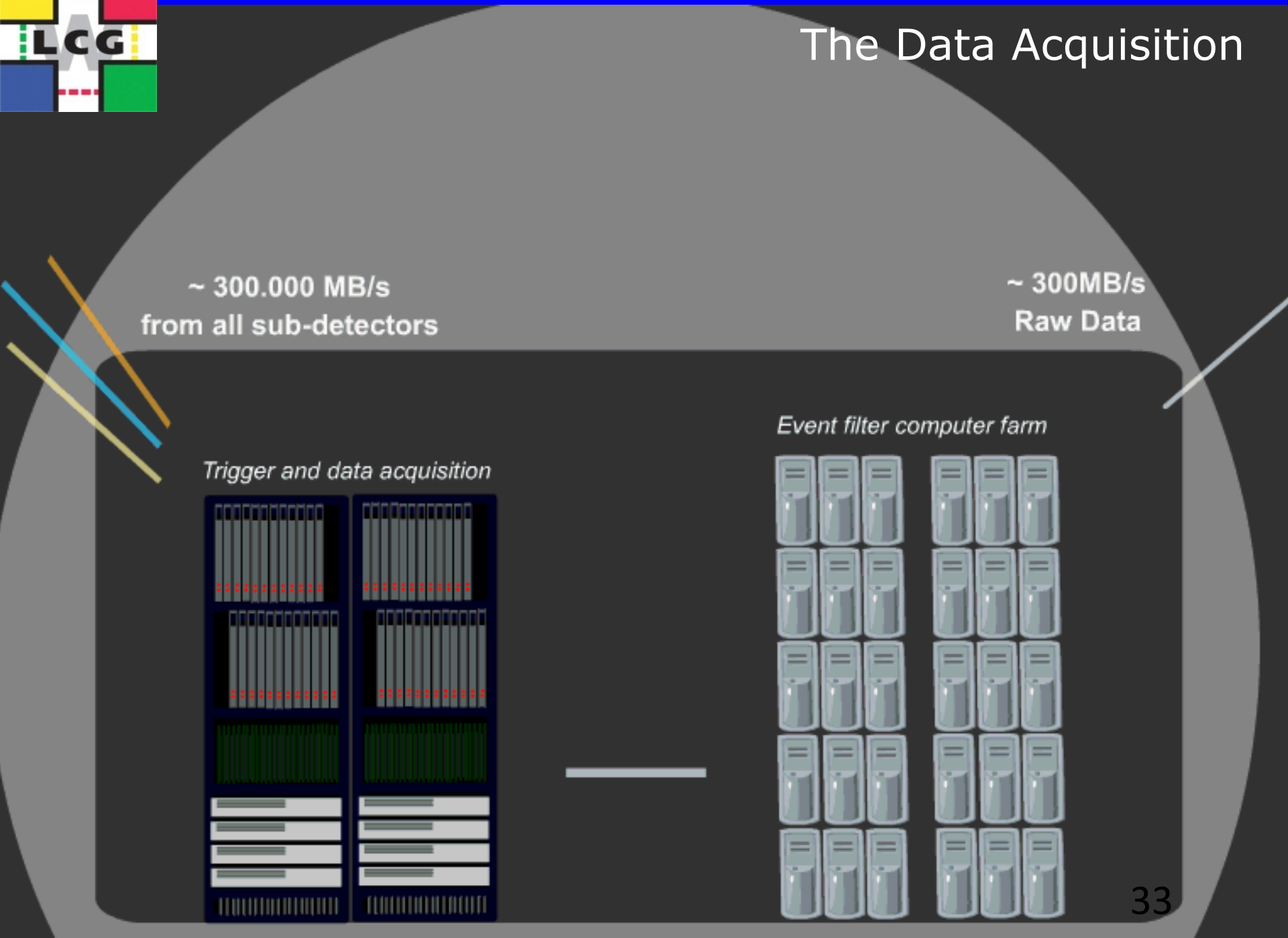




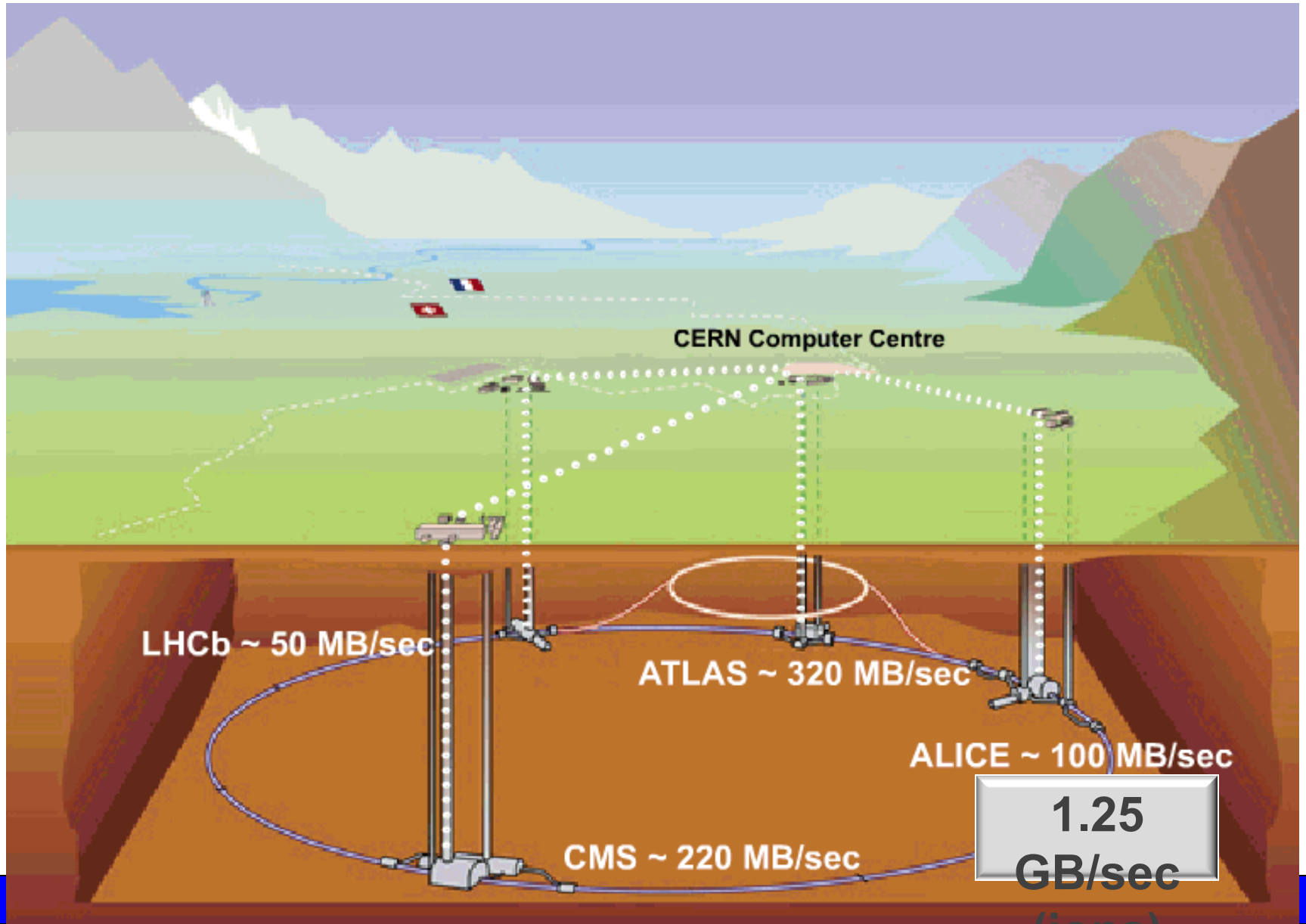
A collision at LHC



The Data Acquisition



Tier 0 at CERN: Acquisition, First pass processing Storage & Distribution



The accelerator will be completed in 2009 and run for 10-15 years

Experiments will produce about **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**

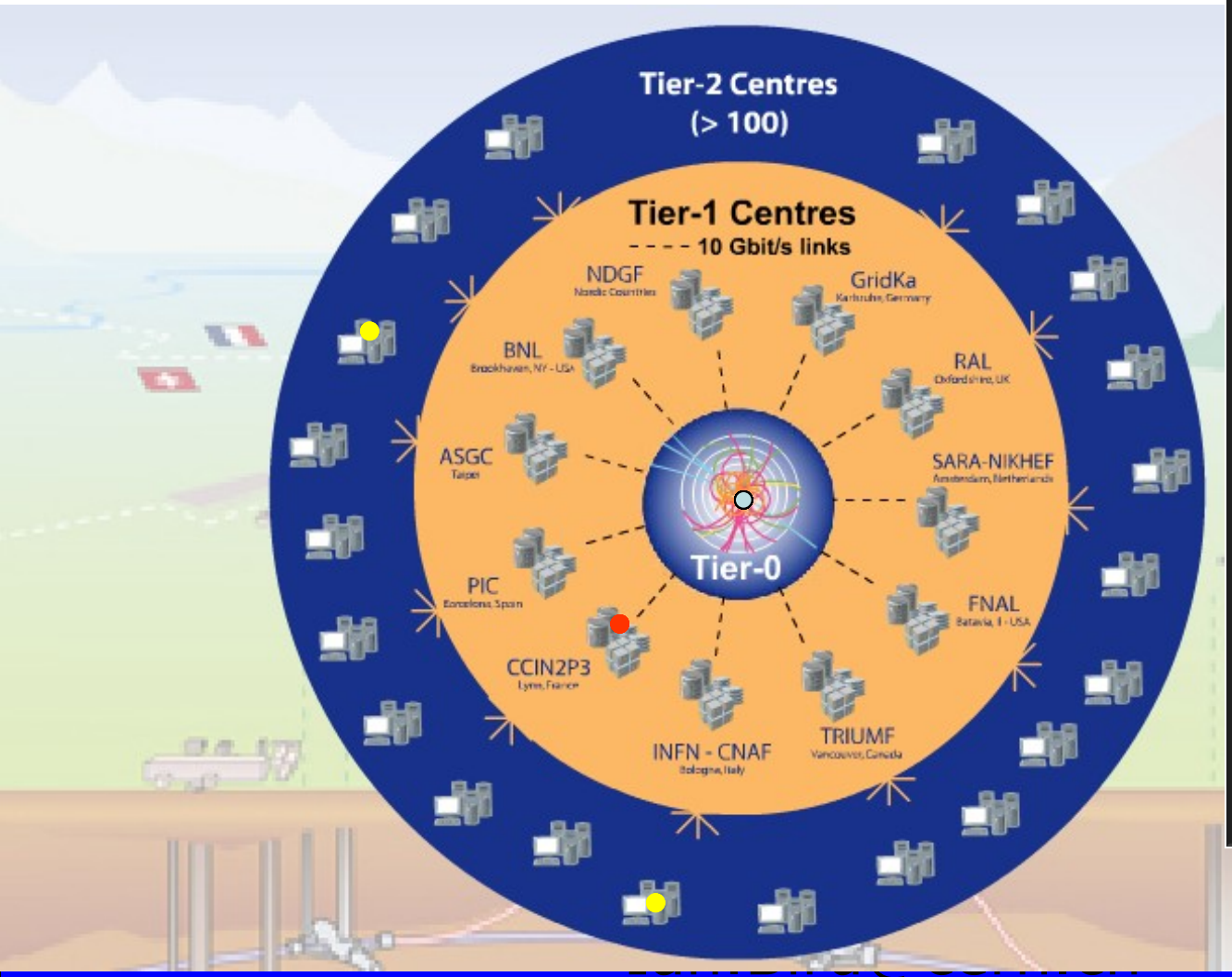
Requires many cooperating computer centres, as CERN can only provide ~20% of the capacity

Use the Grid to unite computing resources of particle physics institutes around the world

The **World Wide Web** provides seamless access to information that is stored in many millions of different geographical locations

The **Grid** is an infrastructure that provides seamless access to computing power and data storage capacity distributed over the globe

Tier 0 – Tier 1 – Tier 2



Tier-0 (CERN):
- Data recording
- Initial data reconstruction
- Data distribution

Tier-1 (11 centres):
- Permanent storage
- Re-processing
- Analysis

Tier-2 (~130 centres):
- Simulation
- End-user analysis

CERN Education Activities

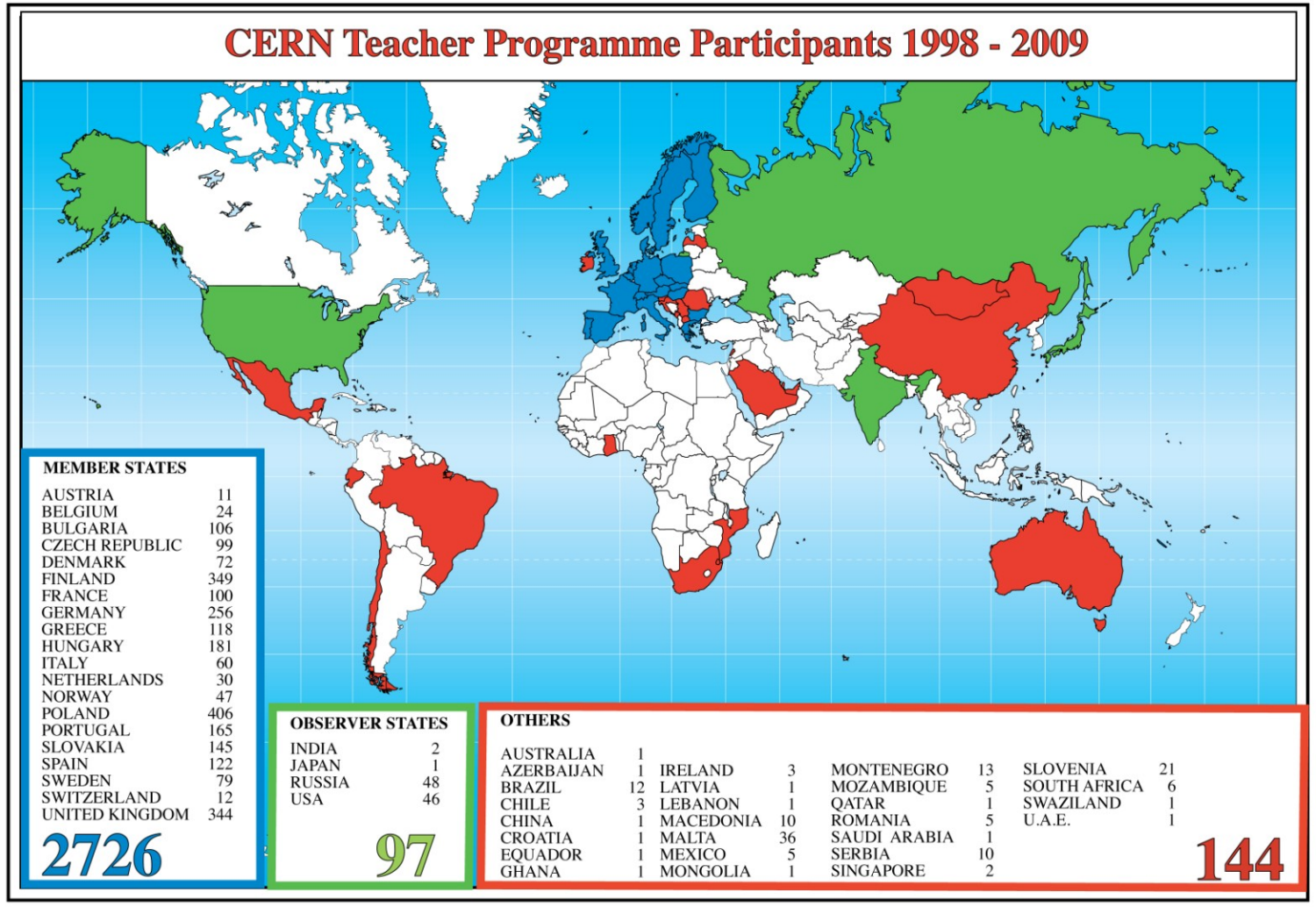
Scientists at CERN
Academic Training Programme

2nd Latin American School of High Energy Physics Mexico, 2003

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

School of Computing Norway, 2008

Physics Students
Summer Students Programme

CERN Teacher Schools
International and National Programmes

CERN Education Activities