

Welcome – Vitajte

Slovakia at CERN

to



Accelerating Science and Innovation

Short History of CERN

- CERN Laboratory was conceived on July 1st, 1953, by and at UNESCO (itself 8 years old at that time, still they consider us as their baby)
- Born after 15 month, on September 29th, 1954 (we are some months after 60 birthday!)
- In the mean time excavation works started on May 17th, 1954



United Nations
Educational, Scientific and
Cultural Organization

• ...and I was born



CERN was founded 1954: 12 European States

“Science for Peace”

Today: 21 Member States

~ 2300 staff
~ 1600 other paid personnel
~ 10500 scientific users
Budget (2014) ~1000 MCHF

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

Candidate for Accession: Romania

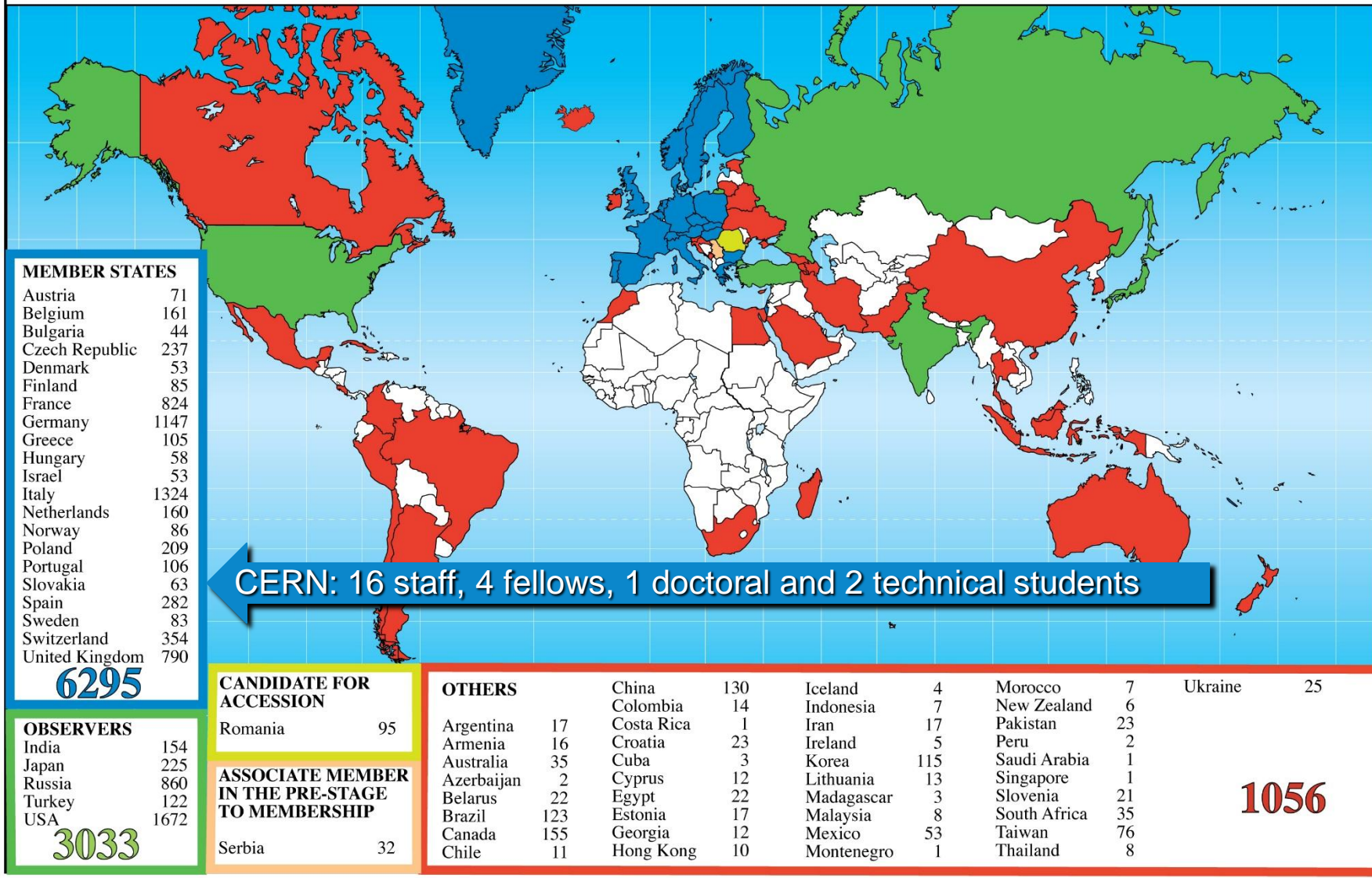
Associate Member in Pre-Stage to Membership: Serbia

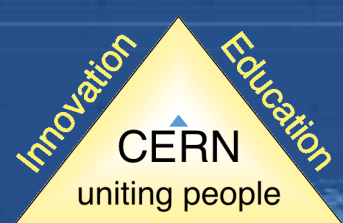
Applicant States for Membership or Associate Membership:
Brazil, Croatia, Cyprus, Pakistan, Russia, Slovenia, Turkey, Ukraine

Observers to Council: India, Japan, Russia, Turkey, United States of America; European Commission and UNESCO

Science is getting more and more global

Distribution of All CERN Users by Location of Institute on 15 September 2014



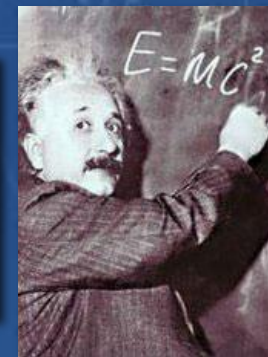


Mission of CERN

Research

❑ **Push forward** the frontiers of knowledge

The secrets of the Big Bang ... what was the matter like within the first moments of the Universe's existence?



❑ **Develop** new technologies
accelerators and detectors

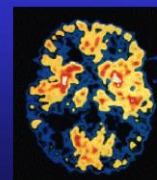
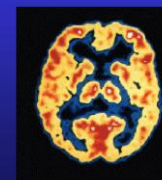
Information technology

Medicine - diagnosis and therapy

CERN
uniting people

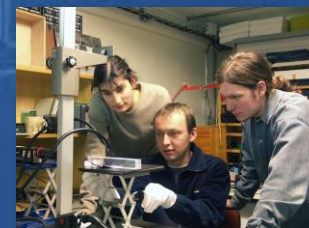


Brain Metabolism in Alzheimer's Disease: PET Scan



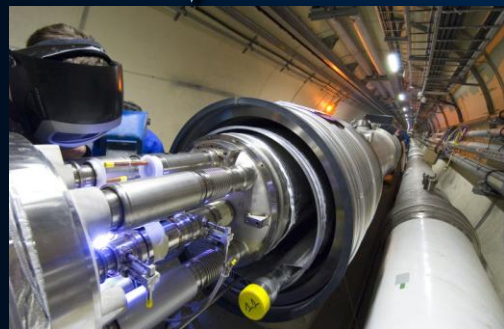
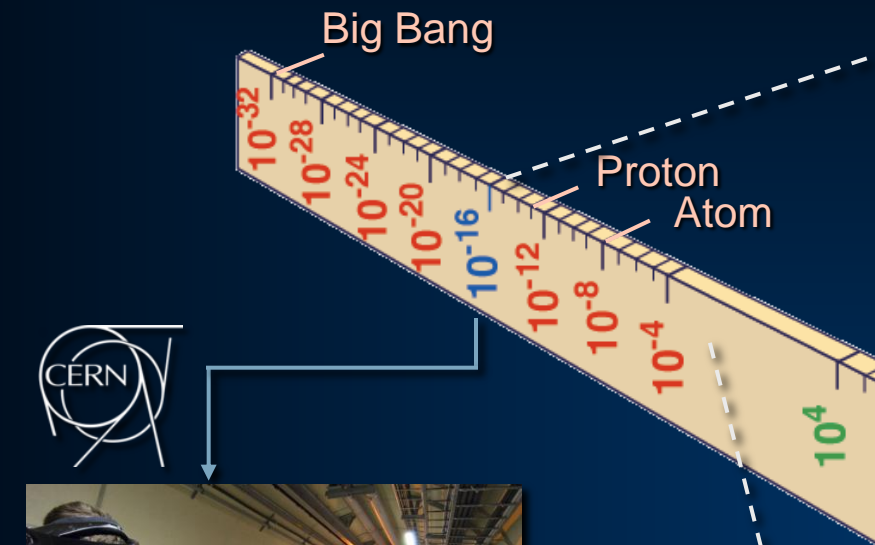
Research

❑ **Train** scientists and engineers of tomorrow



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



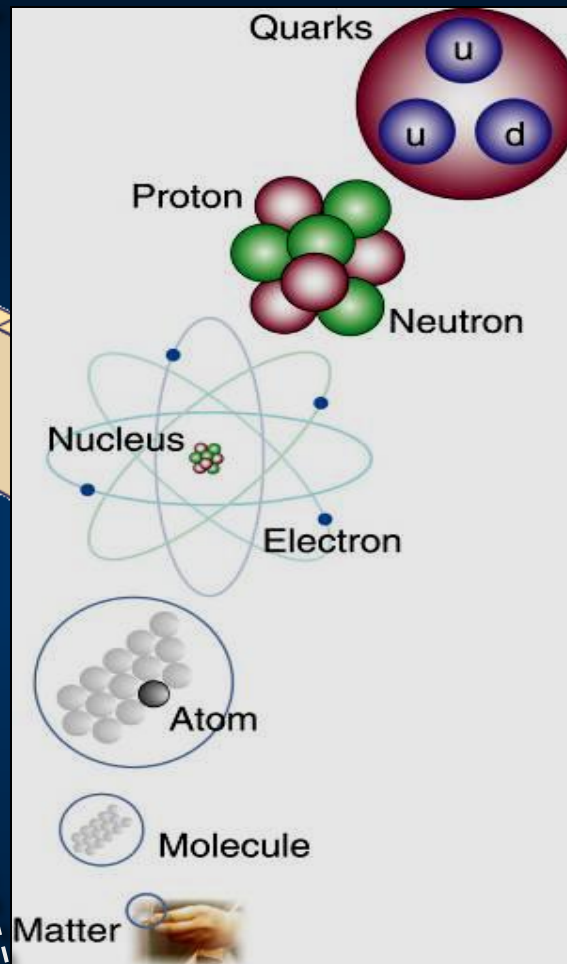


LHC

Super-Microscope

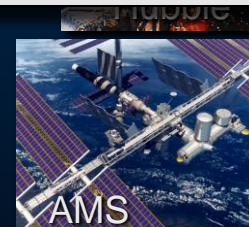
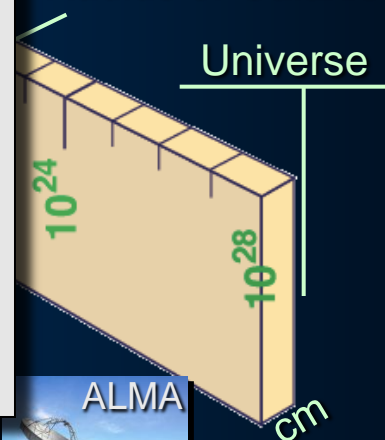


Study physics laws of first moments after Big Bang
increasing Symbiosis between Particle Physics,
Astrophysics and Cosmology



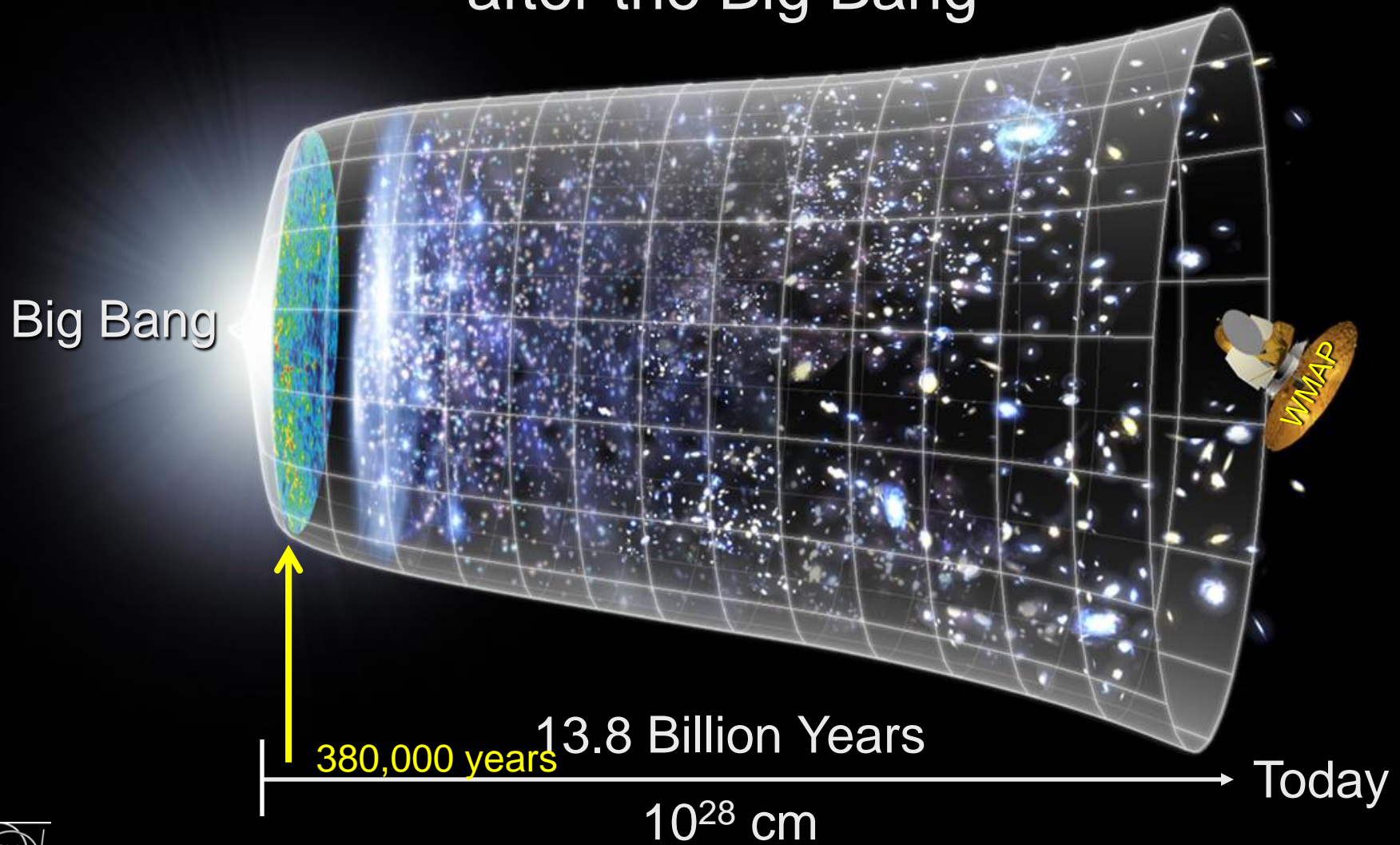
Radius of Galaxies

Universe



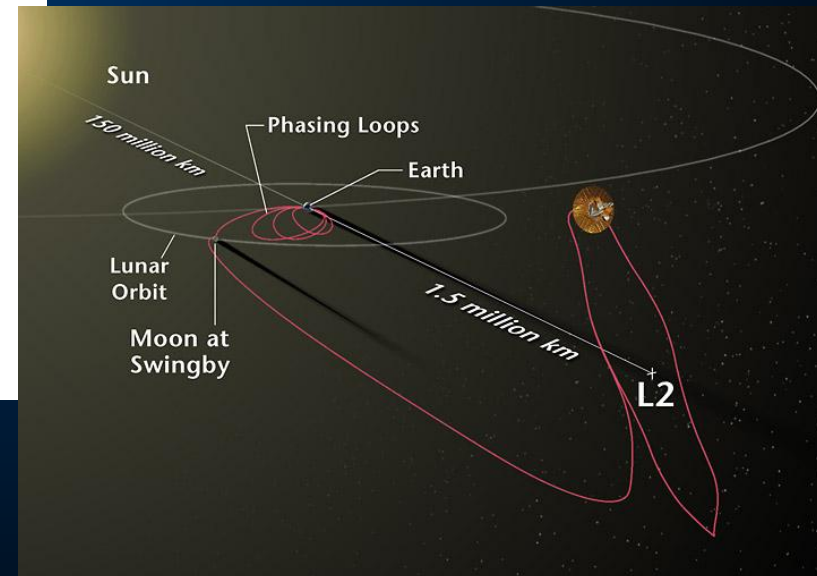
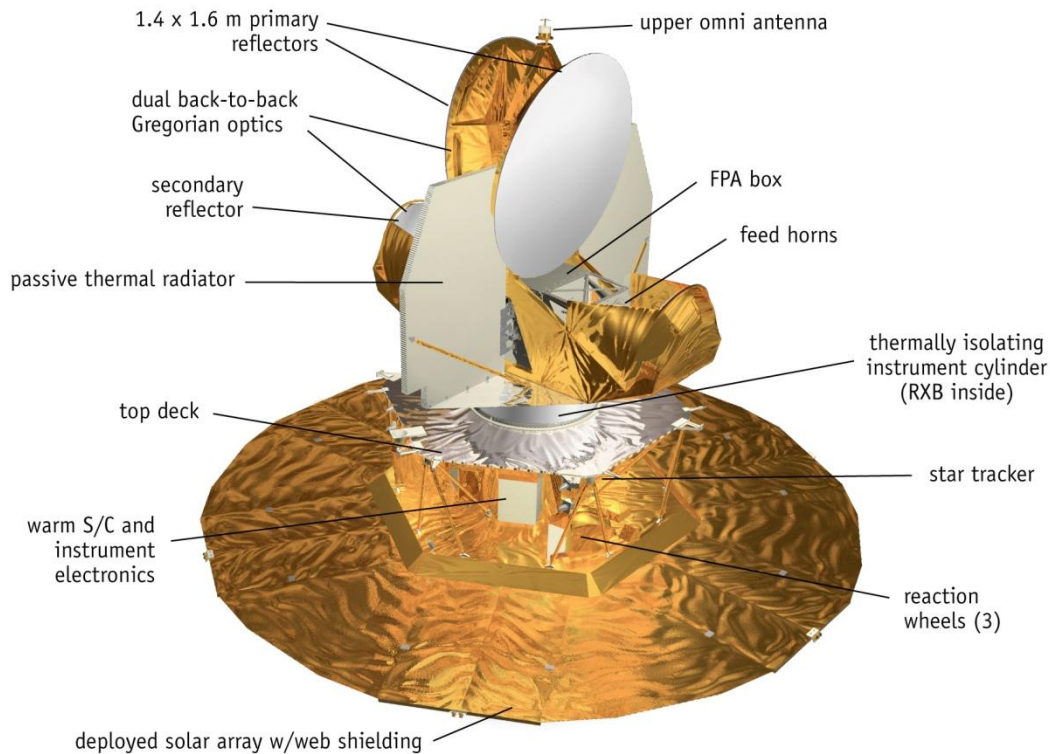
Next Scientific Challenge:

to understand the very first moments of our Universe
after the Big Bang

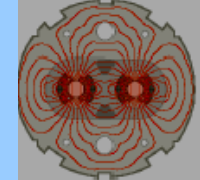


WMAP

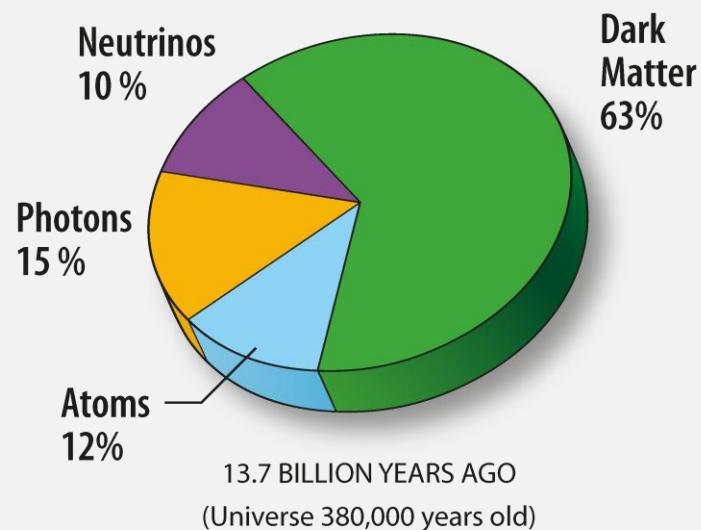
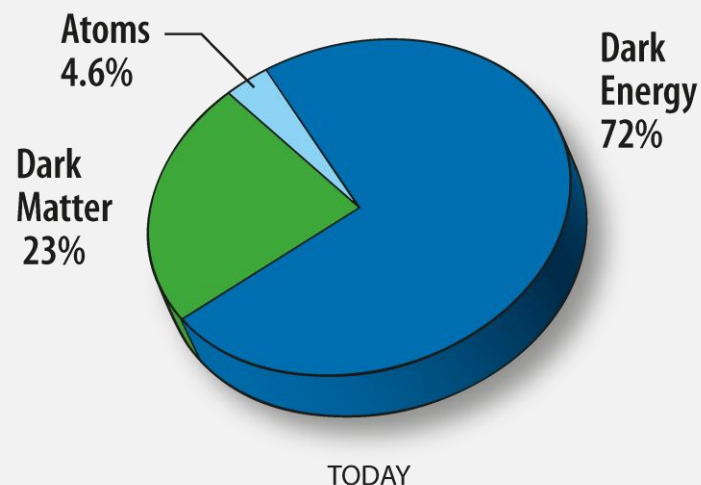
■ Wilkinson Microwave Anisotropy Probe

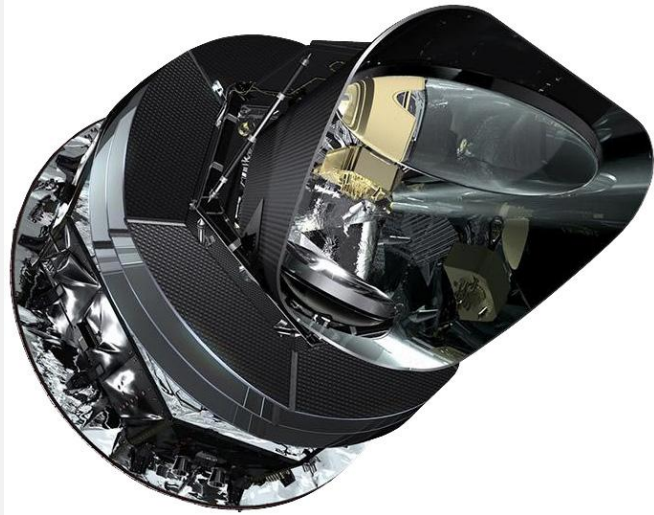
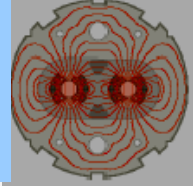


Composition of matter

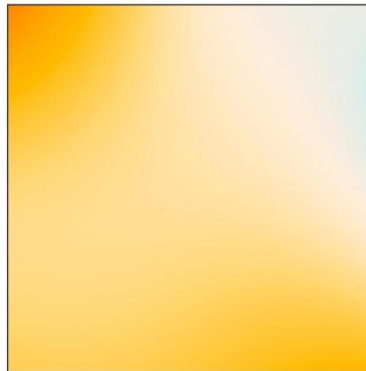


- ◆ today 72% of matter of the Universe – dark energy
- ◆ before $\sim 7 \times 10^9$ years the Universe accelerated its expansion
- ◆ 23% is (cold) dark matter, what is it?
- ◆ vacuum energy? scalar field? cosmological constant?

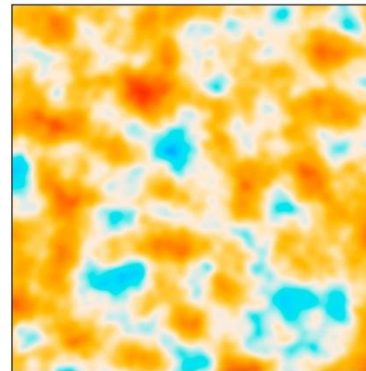
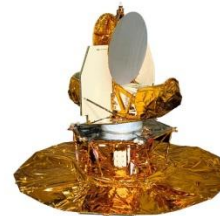




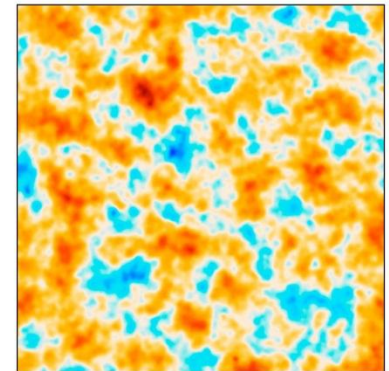
Porovnanie rozlíšania:
10 x lepšie rozlíšenie než WMAP
9 frequency band (WMAP 5)



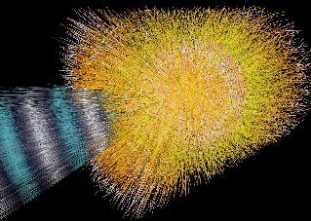
COBE



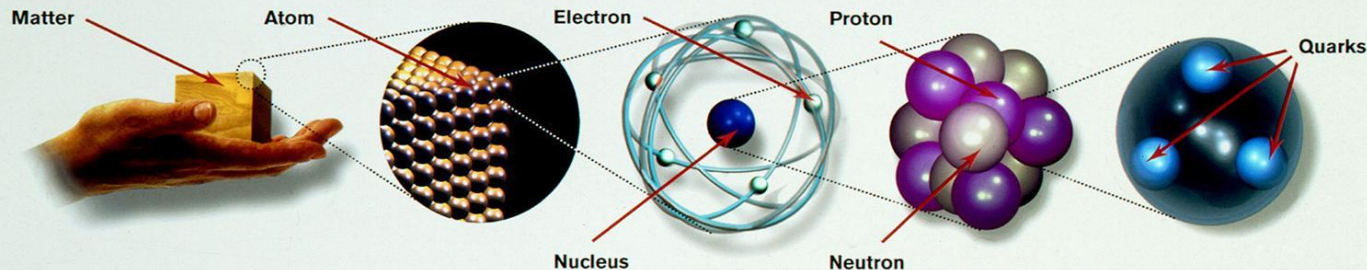
WMAP



Planck



Z čoho sa skladáme ?



Matter particles
All ordinary particles belong to this group

These particles existed just after the Big Bang. Now they are found only in cosmic rays and accelerators

LEPTONS		
FIRST FAMILY	Electron Responsible for electricity and chemical reactions; it has a charge of -1	Electron neutrino Particle with no electric charge, and possibly no mass; billions fly through your body every second
SECOND FAMILY	Muon A heavier relative of the electron; it lives for two-millionths of a second	Muon neutrino Created along with muons when some particles decay
THIRD FAMILY	Tau Heavier still; it is extremely unstable. It was discovered in 1975	Tau neutrino not yet discovered but believed to exist

QUARKS	
Up Has an electric charge of plus two-thirds; protons contain two, neutrons contain one	Down Has an electric charge of minus one-third; protons contain one, neutrons contain two
Charm A heavier relative of the up; found in 1974	Strange A heavier relative of the down; found in 1964
Top Heavier still	Bottom Heavier still; measuring bottom quarks is an important test of electroweak theory

Force particles
These particles transmit the four fundamental forces of nature, although gravitons have so far not been discovered

Gluons
Carriers of the strong force between quarks

Felt by: quarks

The explosive release of nuclear energy is the result of the **strong force**

Photons
Particles that make up light; they carry the electromagnetic force

Felt by: quarks and charged leptons

Electricity, magnetism and chemistry are all the results of **electro-magnetic force**

Intermediate vector bosons
Carriers of the weak force

Felt by: quarks and leptons

Some forms of radio-activity are the result of the **weak force**

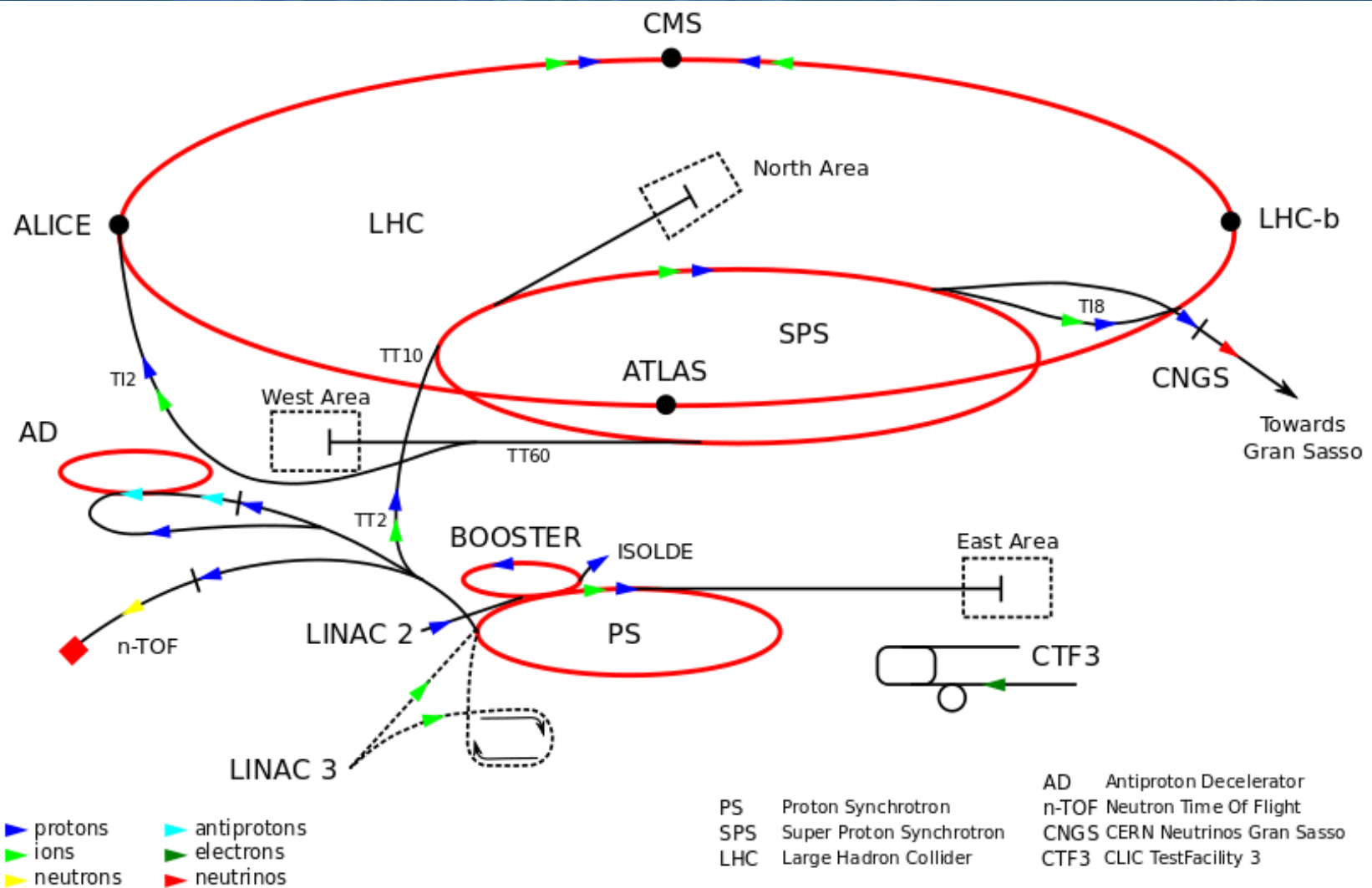
Gravitons
Carriers of gravity

Felt by: all particles with mass

All the weight we experience is the result of the **gravitational force**

CERN Accelerators

- CERN accelerator complex always reused as much as possible previously built machines in the injection chain



Neutral Currents

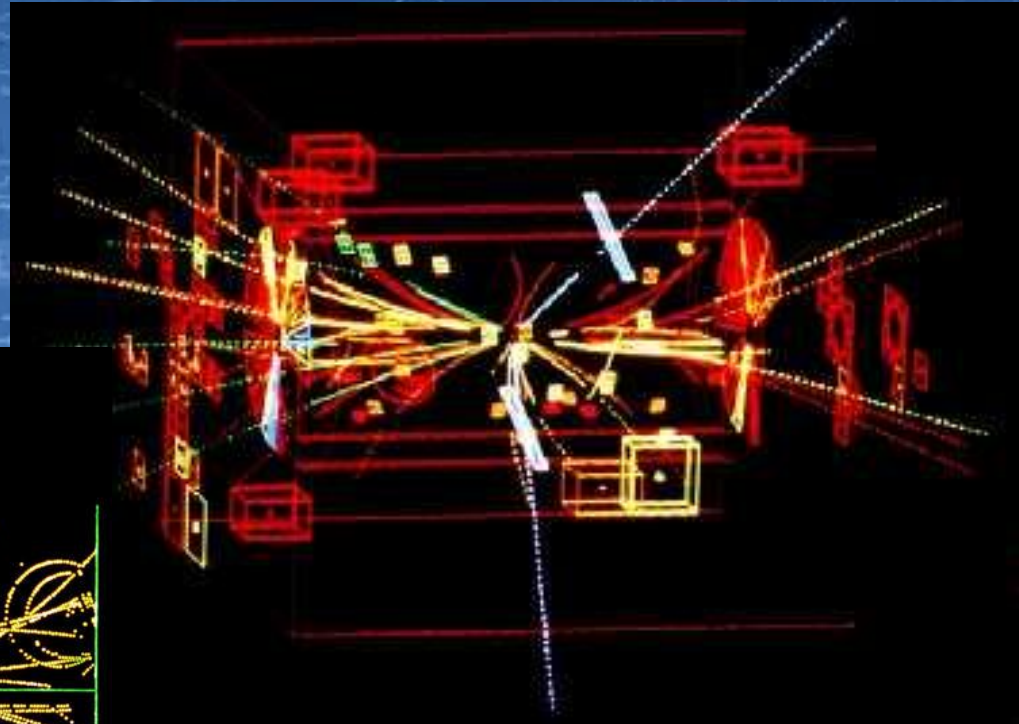
- Predicted as consequence of electro-weak unification
- Discovered in 1973 with Gargamelle bubble chamber exposed to ν_μ -beam from PS – neutrino scatters on electron without producing μ
- Indication for existence of Z boson



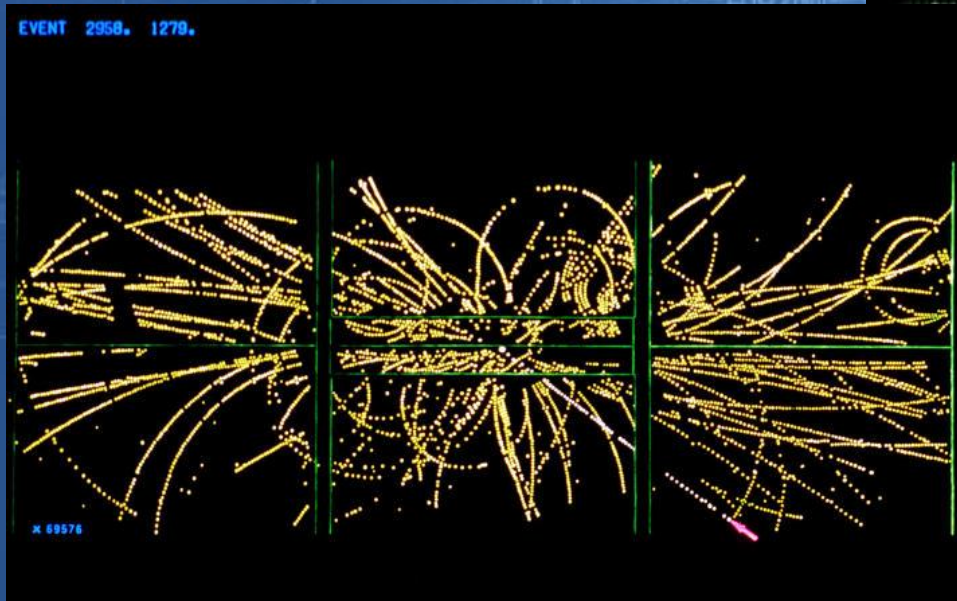
W and Z Bosons

- In 1983 discovery of W and Z bosons – the carriers of electro-weak interactions was announced by UA1 and UA2 experiments

UA1 Z-boson candidate

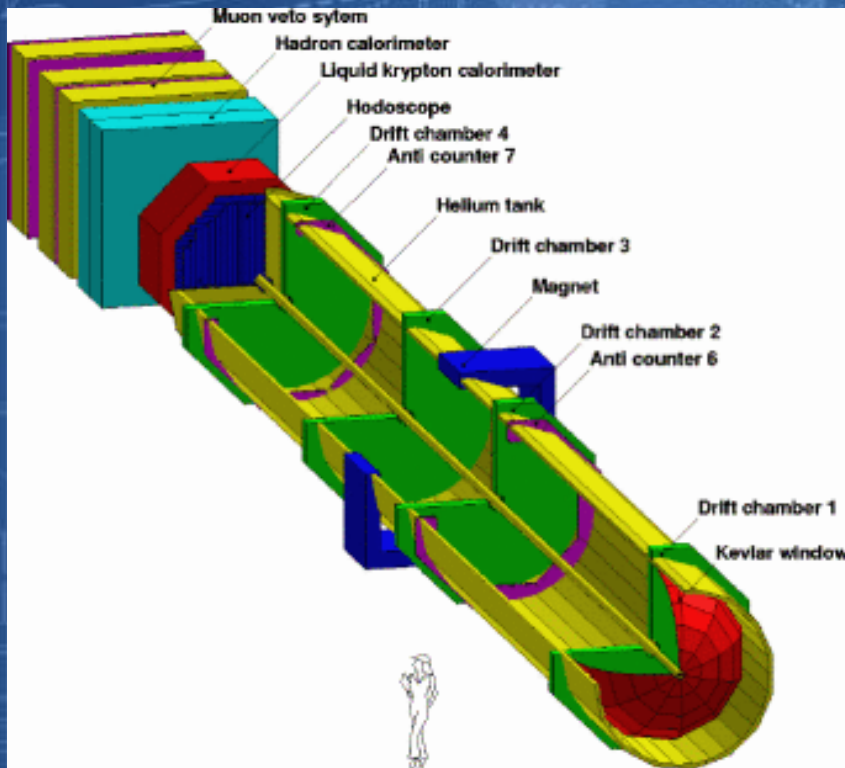


UA2 W-boson candidate



CP Violation

- Discovered in neutral kaon system in 1964
- In 1988 NA38 experiment at SPS evidence for direct CP violation
- Confirmed in 1999 by NA48 and KTeV at FermiLab
- Key to understand the asymmetry between matter and antimatter in early Universe



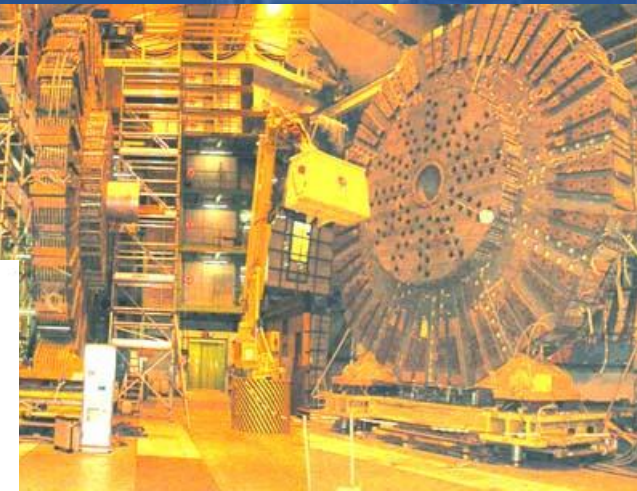
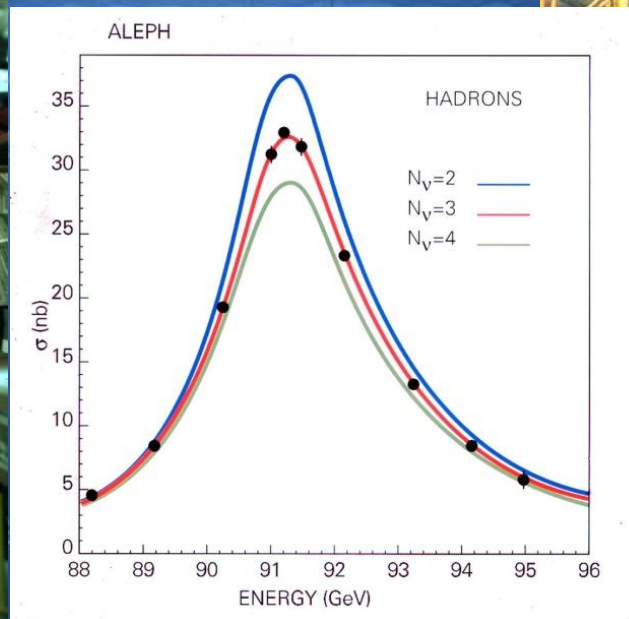
LEP

- Large Electron–Positron collider project approved in May 1981
- Built in 27 km tunnel between 1983 and 1988, commissioned in 1989
- Operated around 90 GeV, in second phase since 1995 topped at 209 GeV
- Closed down in 2000 to make way for LHC

DELPHI

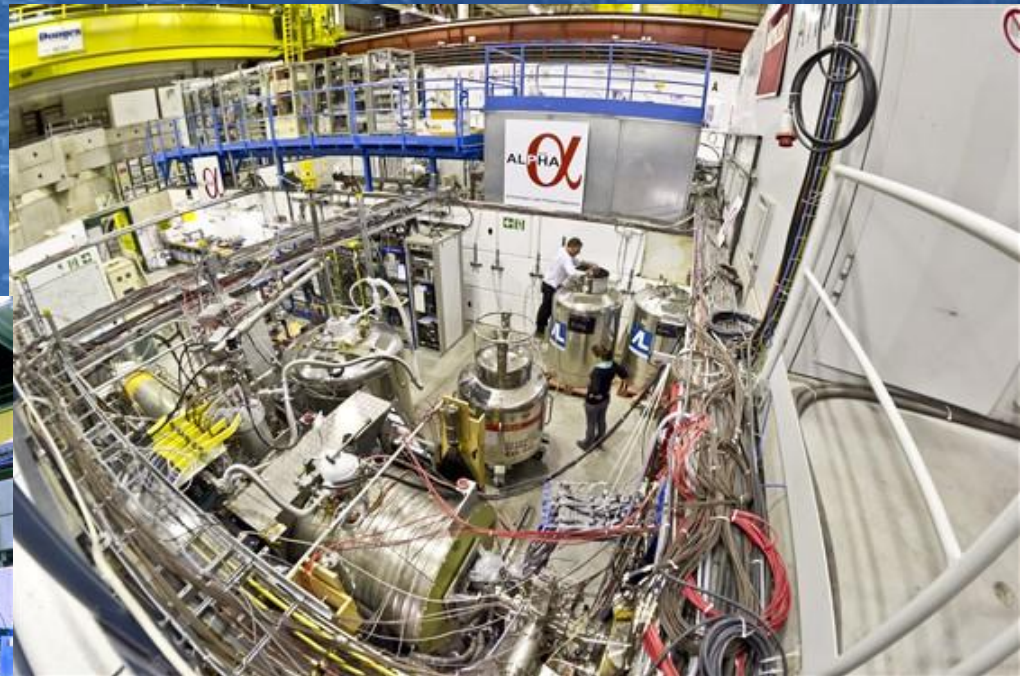


three generations



Antimatter

- In 1995 the first atoms of antihydrogen produced at LEAR in PS210
- ATHENA and ATRAP reported many antihydrogens in 2002
- In 2011 experiment ALPHA at AD captured antiatoms for more than 15'



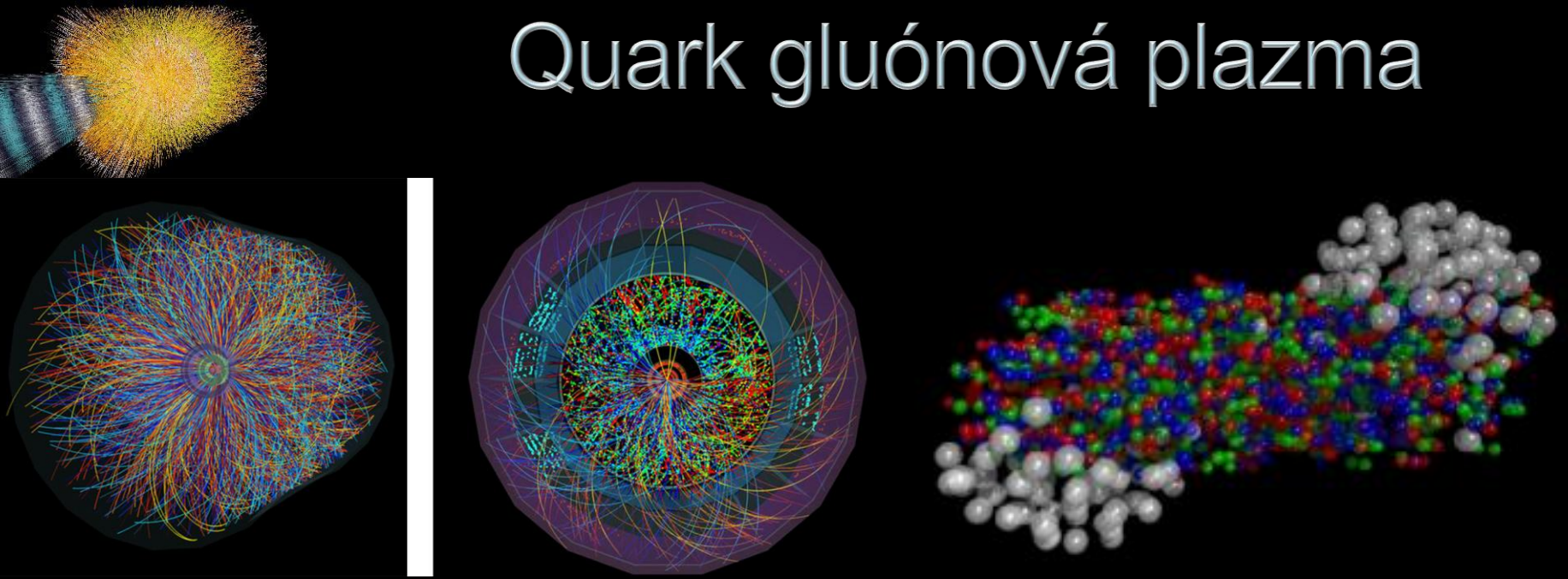
AMS – Alpha Magnetic Spectrometer



Experiment AMS potvrdil, že vidí signál, ktorý by mohol pochádzať od čiernej hmoty

LHC ma potenciál tento jav zreprodukovat'

Quark gluónová plazma



- Experimenty na SPS nepriamo ukázali, že existuje nová forma hmoty – quark gluónová plazma
- Vyrobili sme kvapku hmoty aká existovala niekoľko milióntin sekundy po vzniku Vesmíru
- Experimenty na LHC potvrdili existenciu QGP priamo a začali skúmať jej vlastnosti

LHC

- Large Hadron Collider project – multiple staged approval since 1994
- Built in the former LEP 27 km tunnel between 2003 and 2008
- In the same period four main experiments installed
 - ALICE – specialized for heavy-ion collisions
 - ATLAS – general purpose pp experiment
 - CMS – general purpose pp experiment
 - LHCb – specialized experiment for beauty physics
- First proton beam circulated in LHC on September 10th 2008
- An incident due to faulty electrical connection interrupted commissioning
- Restarted one year later, first collisions on November 23rd 2009 at 0.9 TeV, till the end of that year increased to 2.3 TeV – new world record
- In 2010 pp collisions at 7 TeV, in the fall first PbPb collisions at 2.76 TeV/n
- In 2011 increase in luminosity, first high-luminosity PbPb run
- Energy increase to 8 TeV in 2012, first pPb collisions, continued in 2013
- Till beginning of 2015 the first long shutdown to prepare further energy increase up to 13 TeV

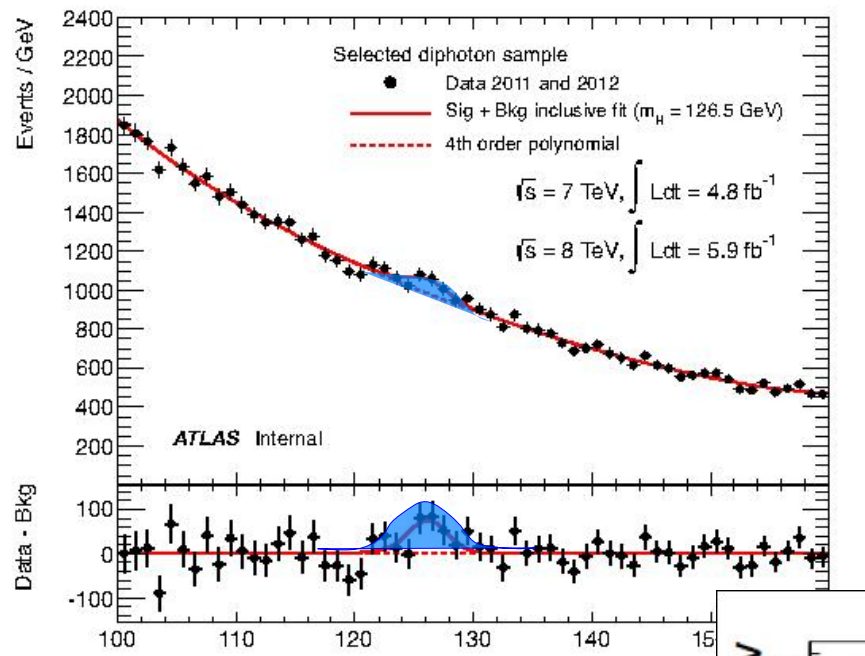


2010: a New Era in Fundamental Science

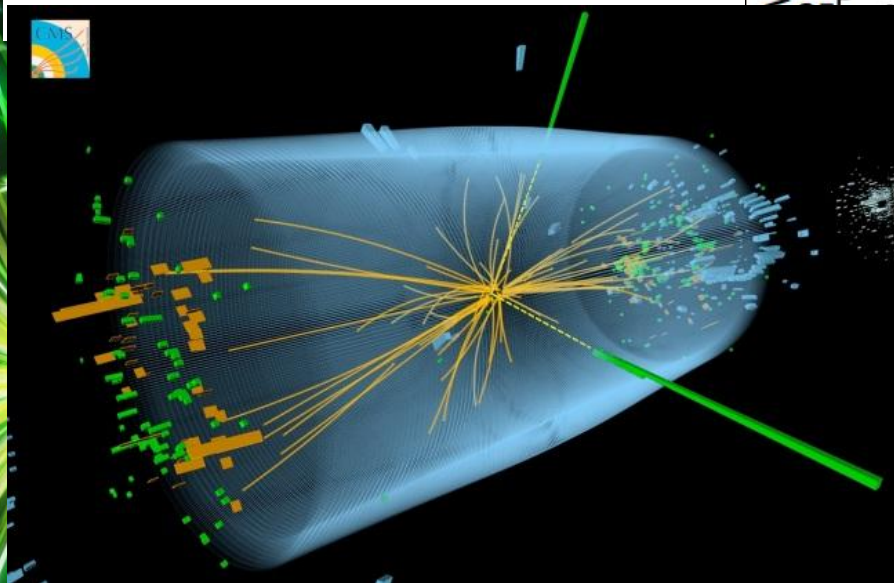
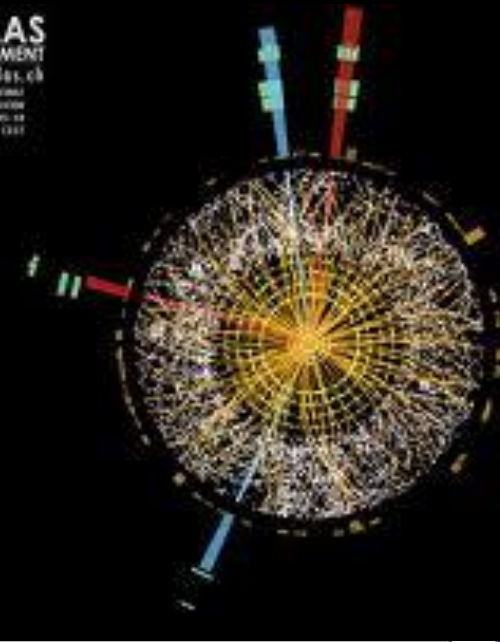


LHC





ATLAS
EXPERIMENT
<http://atlas.ch>
Name: J. H. Kühn
E-mail: jkuhn@atlas.ch
Date: 2012-05-18
Time: 09:28:44 CEST

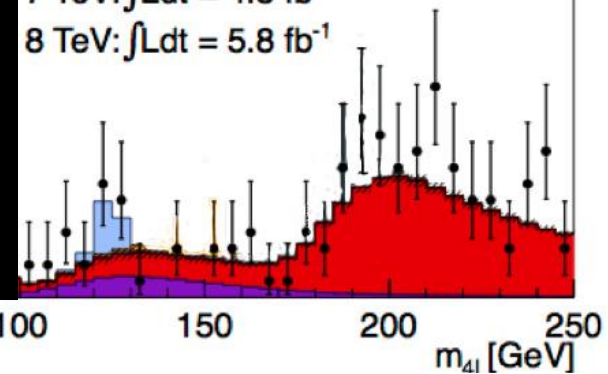


Data
Background ZZ
Background Z+jets, $t\bar{t}$
Signal ($m_H = 125$ GeV)

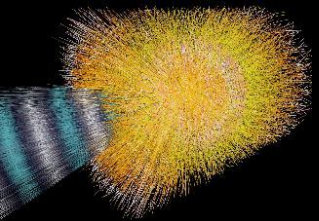
ATLAS Preliminary

$H \rightarrow ZZ^{(*)} \rightarrow 4l$

7 TeV: $\int L dt = 4.8 \text{ fb}^{-1}$
8 TeV: $\int L dt = 5.8 \text{ fb}^{-1}$

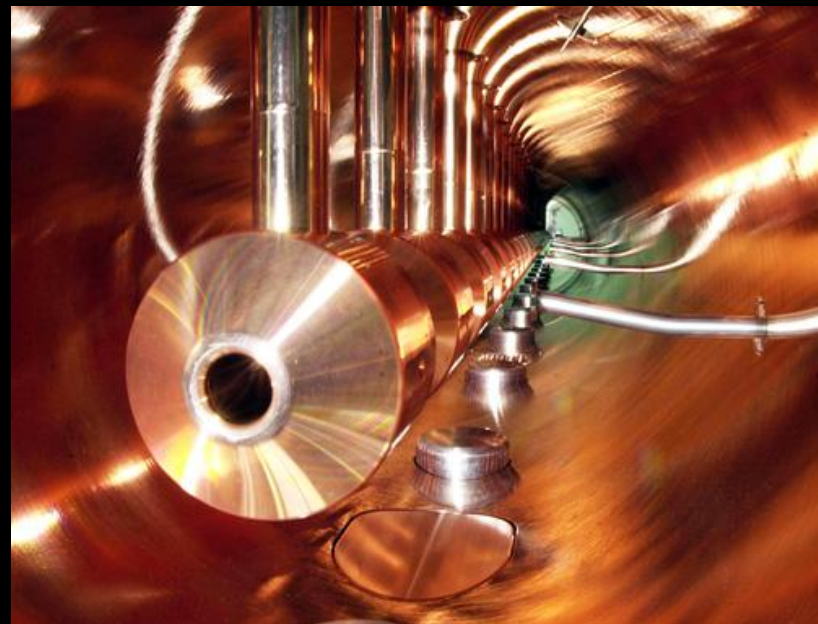


Experimenty ATLAS a CMS objavili novú časticu, vážiacu 126 GeV



Urýchľovače nie sú iba pre fyziku

- Urýchľovače sa bežne využívajú mimo fyziky
- Vo svete je 17000 urýchľovačov z toho iba 100 slúži na výskum
- Využitie urýchľovačov
 - ▣ Výroba polovodičových obvodov
 - ▣ Výroba radiofarmák, terapia nádorov, medicínska diagnostika
 - ▣ Analýza štruktúr proteínov vo farmácii, výskum DNA
 - ▣ Likvidácia jadrových odpadov
 - ▣ ...



Ion Implanter
(Varian Associates)



CERN: Particle Physics and Innovation

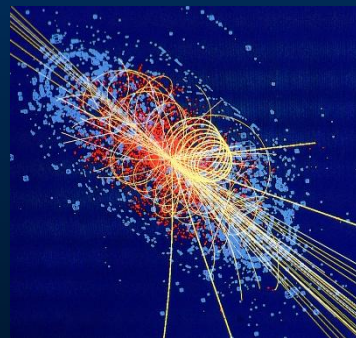
- ❑ **Interfacing** between fundamental science and key technological developments



- ❑ **CERN Technologies and Innovation**



Accelerating particle beams



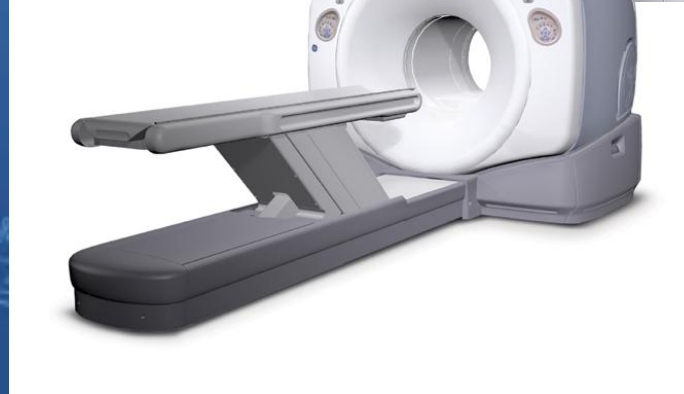
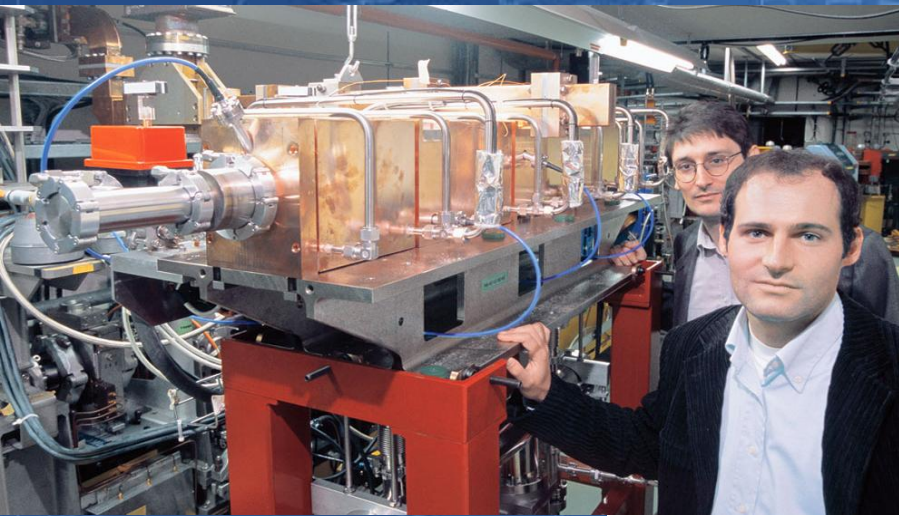
Detecting particles



Large-scale computing (Grid)

New Technologies

- Many examples of technological developments successfully transferred to society
- Medical applications: PET scanners, hadron therapy, diagnostic detection
- Computing technologies: World Wide Web, GRID





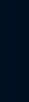
Slovakia and CERN



- ❑ Slovakia became **CERN Member State** in 1993
- ❑ Today research in particle physics is carried out mainly at 4 Institutes:
 - ❑ Comenius University Bratislava
 - ❑ Institute of Experimental Physics of the Slovak Academy of Sciences, Košice
 - ❑ Institute of Physics of the Slovak Academy of Science, Bratislava
 - ❑ Šafárik University Košice



Concentrated effort to participate in the **LHC** experiments **ALICE** and **ATLAS**:
Total 31 members from
Comenius University and
Institute of Experimental Physics of the
Slovak **Academy of Sciences**, Košice



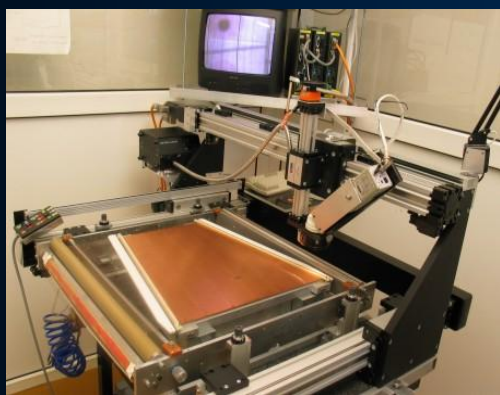


Slovakia and CERN



Contributions to ALICE

16 members



TPC **Bratislava**
Production and test
of 26 readout
chambers at
Bratislava Detector
Laboratory



Pixel detector:
Košice
Electronics for
readout



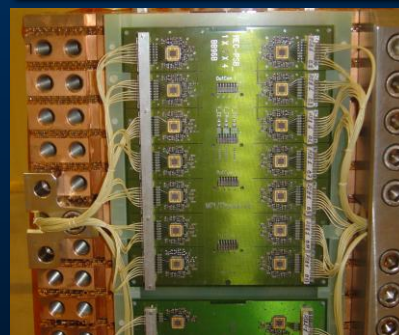
Contributions to ATLAS

15 members



Tile calorimeter in test beam

Tile calorimeter:
Bratislava
Iron tiles produced
in Dubnica



Electronics cards for LAr
endcap calorimeter:
Košice

Lifting devices for calorimeter modules produced in Prešov





Slovakia and CERN



Contributions to LHC project from Industry in Slovakia

Blue cryostat for
LHC dipoles
produced at SES
(Slovenské
energetické
strojárne, Tlmače)



Robots carry LHC magnets and
align them with magnet support
jacks made by ZŤS (Závody
ťažkého strojárstva, Košice)



LHC award to ZTS



**KAŽDÁ
LÁSKA
ZAČÍNÁ
VELKÝM
TRESKOM**

