



CMS 2012 Workshop

High School Teachers Programme



Alushta, 29 May 2012

Greetings from CERN



Introduction to CERN & Educational opportunities at CERN

Tadeusz KURTYKA – CERN



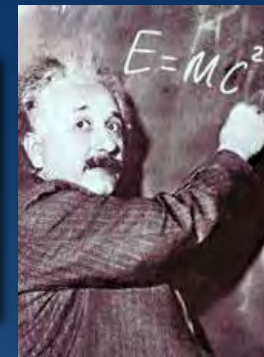
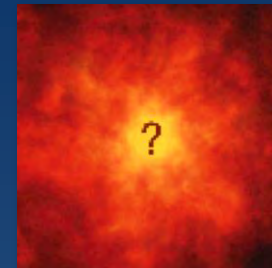
Accelerating Science and Innovation



The Mission of CERN

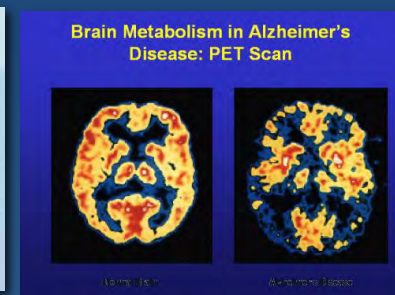
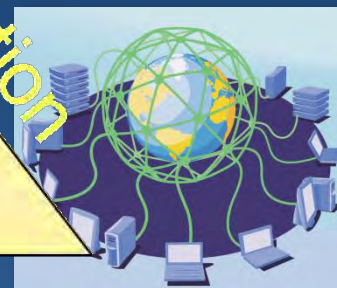
- **Push back** the frontiers of knowledge

E.g. the secrets of the Big Bang, what does matter like within the first moments of the universe's existence?



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

Information technology
Medicine - diagnosis and therapy



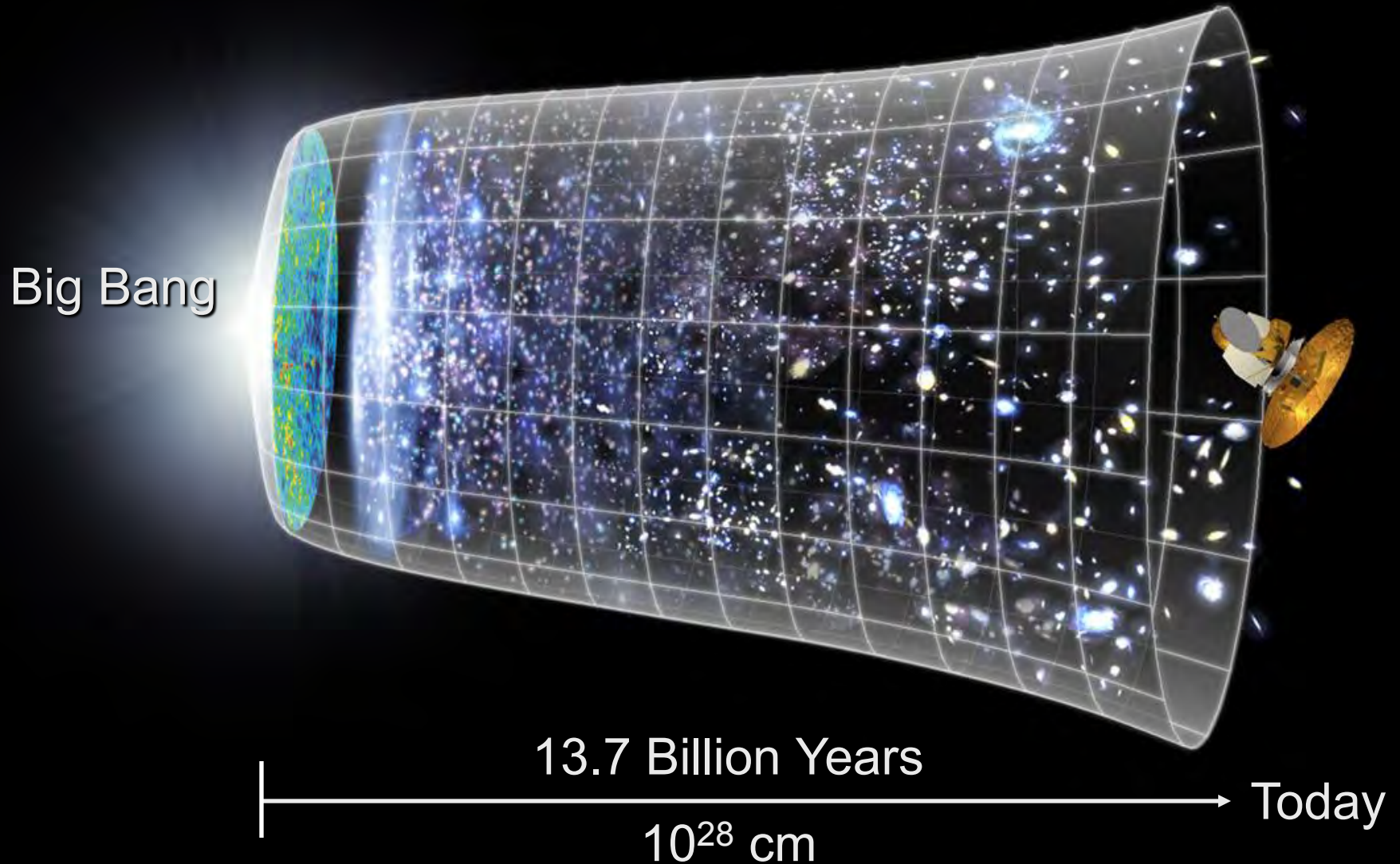
- **Train** scientists and engineers of tomorrow

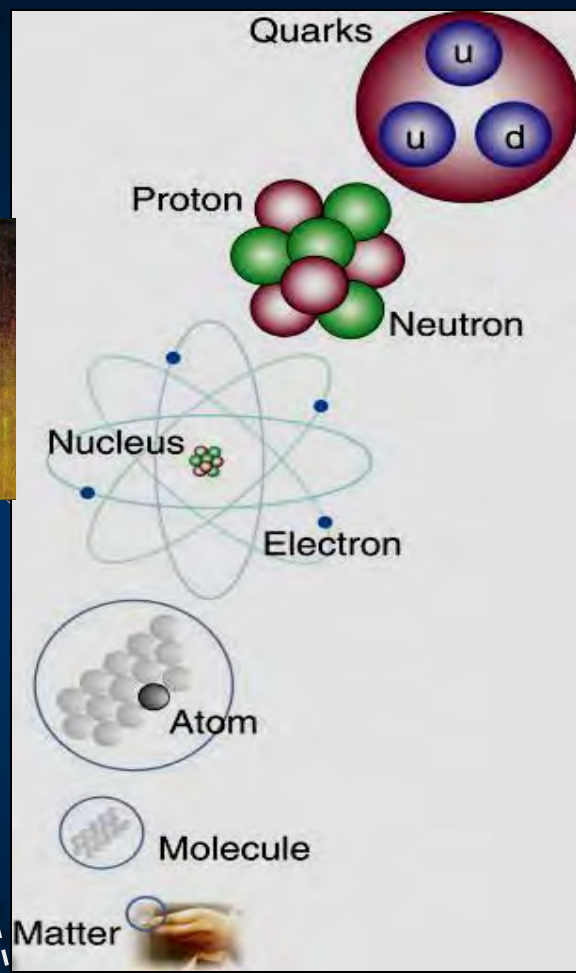
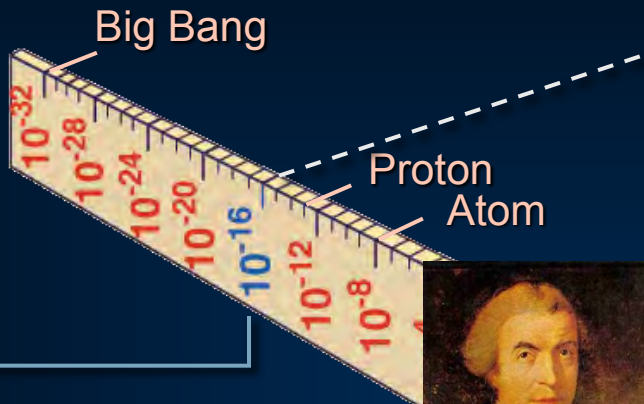


- **Unite** people from different countries and cultures



Evolution of the Universe





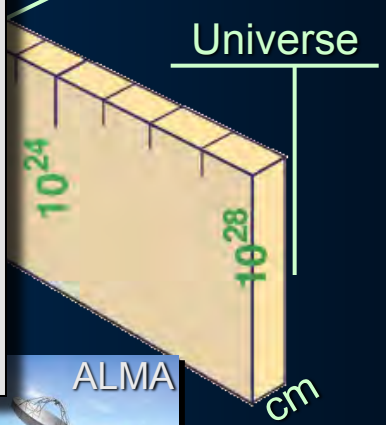
LHC

Super-Microscope



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

Radius of Galaxies



A New Era in Fundamental Science



CMS



LHCb



ATLAS



Exploration of a new energy frontier
in p-p and Pb-Pb collisions



LHC ring:
27 km circumference



ALICE

CERN was founded 1954: 12 European States

“Science for Peace”

Today: 20 Member States



~ 2300 staff

~ 790 other paid personnel

> 10000 users

Budget (2011) ~1000 MCHF

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

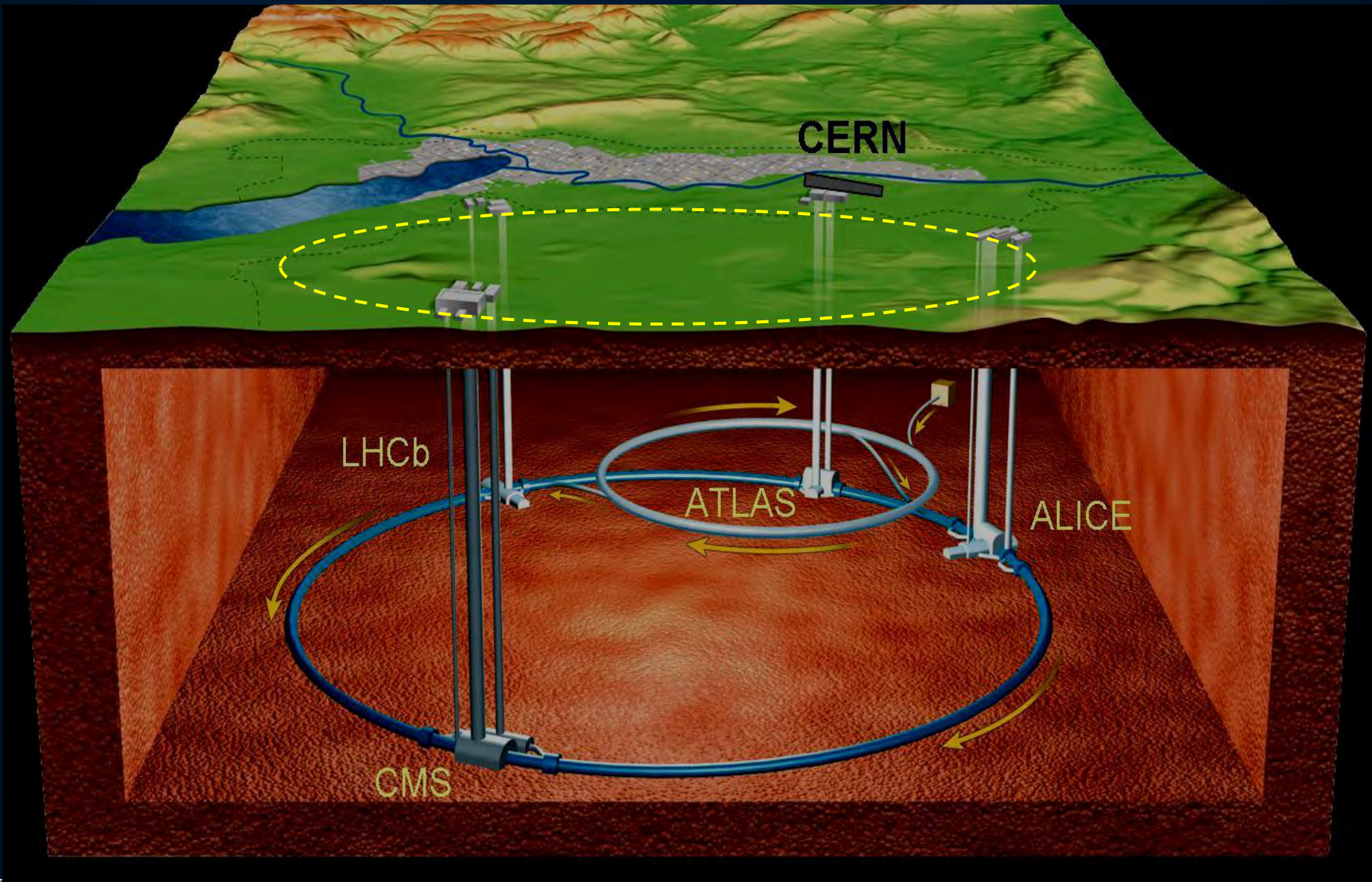
Candidate for Accession: Romania

Associate Member in the Pre-Stage to Membership: Israel, Serbia

Applicant States: Cyprus, Slovenia, Turkey

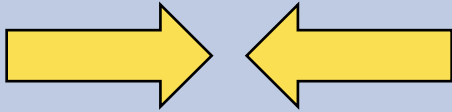
Observers to Council: India, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO

LHC – Large Hadron Collider

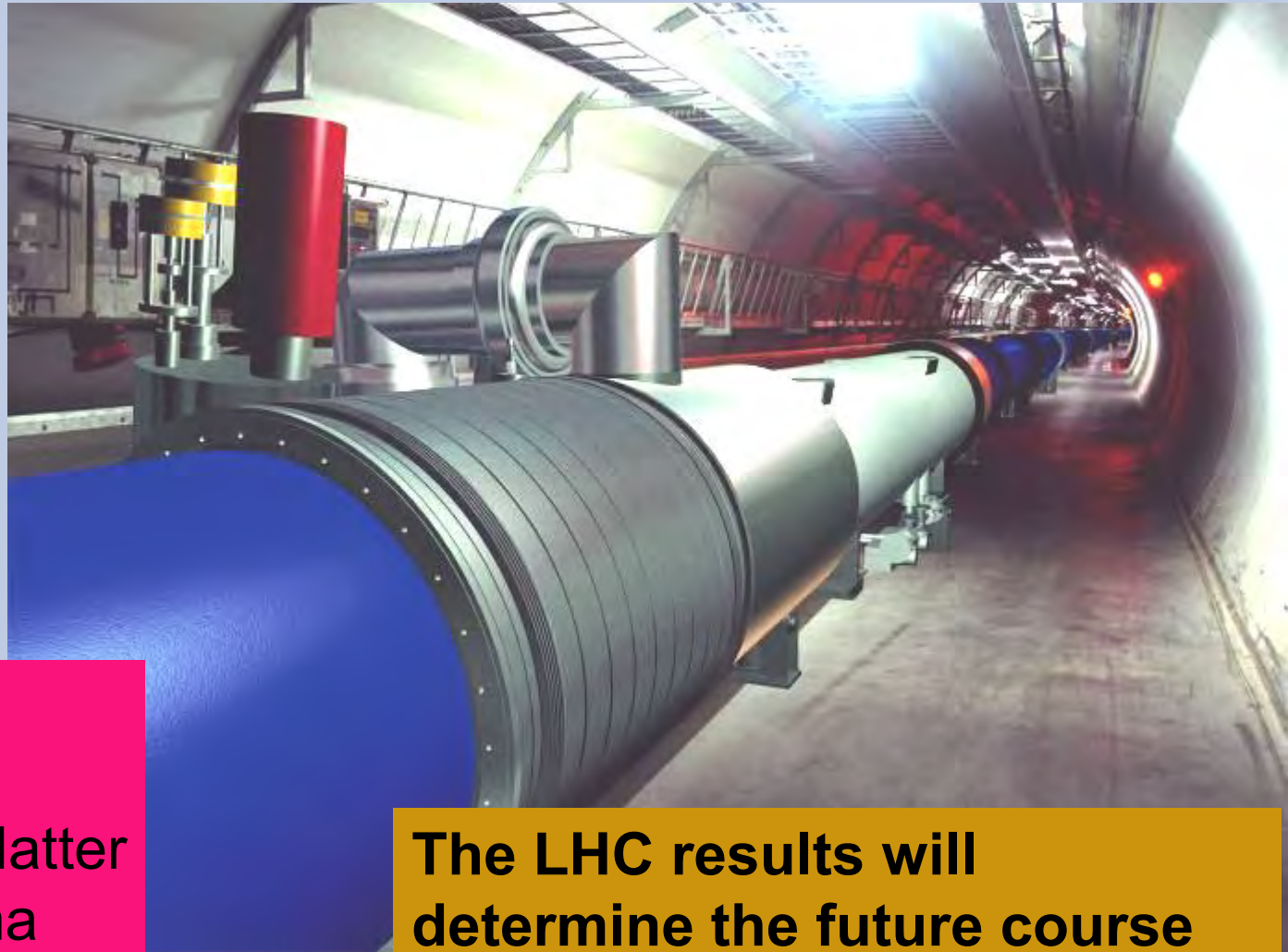


LHC - Large Hadron Collider

7 TeV + 7 TeV



Luminosity =
 $10^{34} \text{cm}^{-2} \text{sec}^{-1}$



Primary targets:

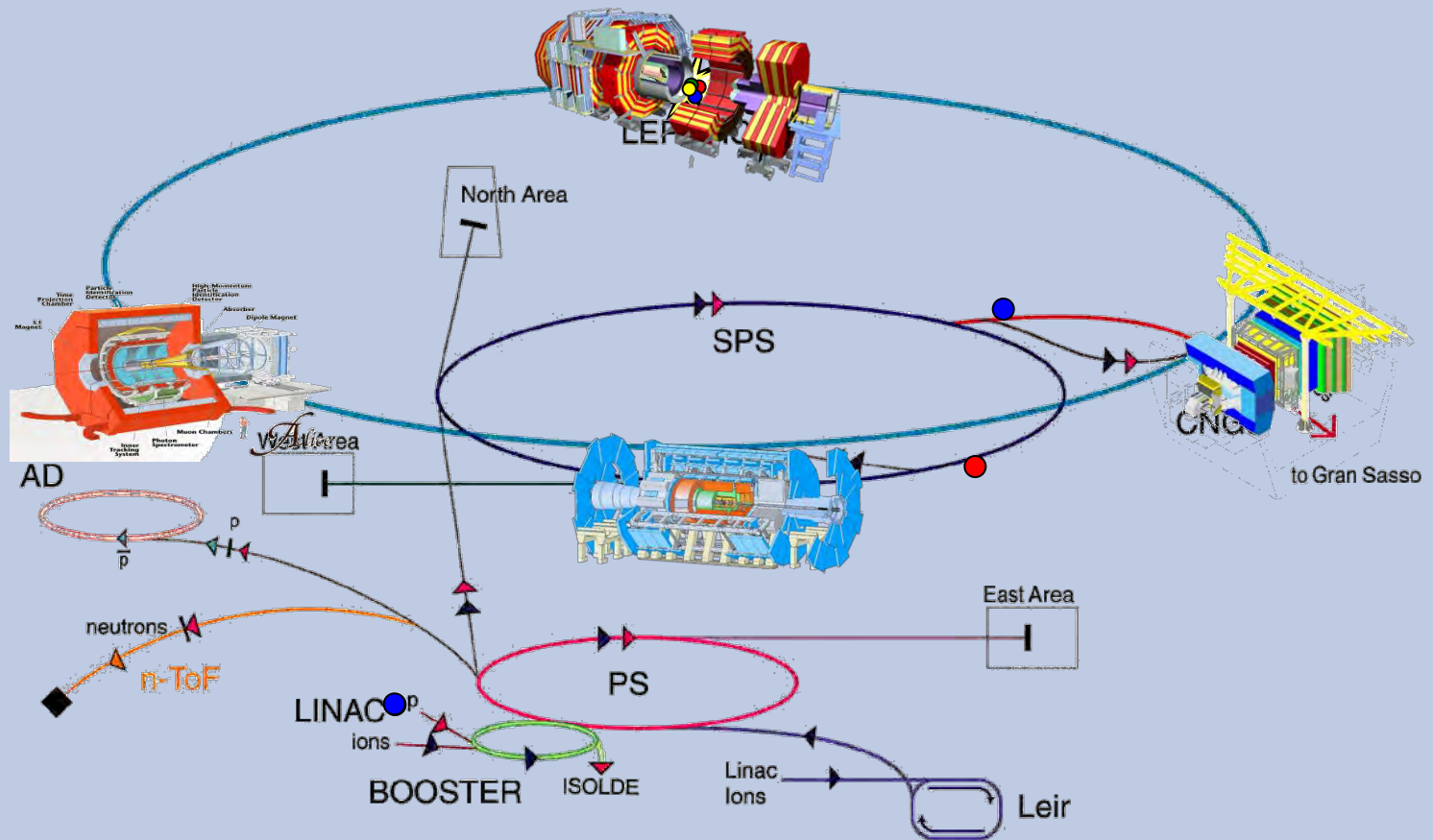
- Origin of mass
- Nature of Dark Matter
- Primordial Plasma
- Matter vs Antimatter

The LHC results will determine the future course of High Energy Physics

Large Hadron Collider

Collision of proton beams...

...observed in giant detectors

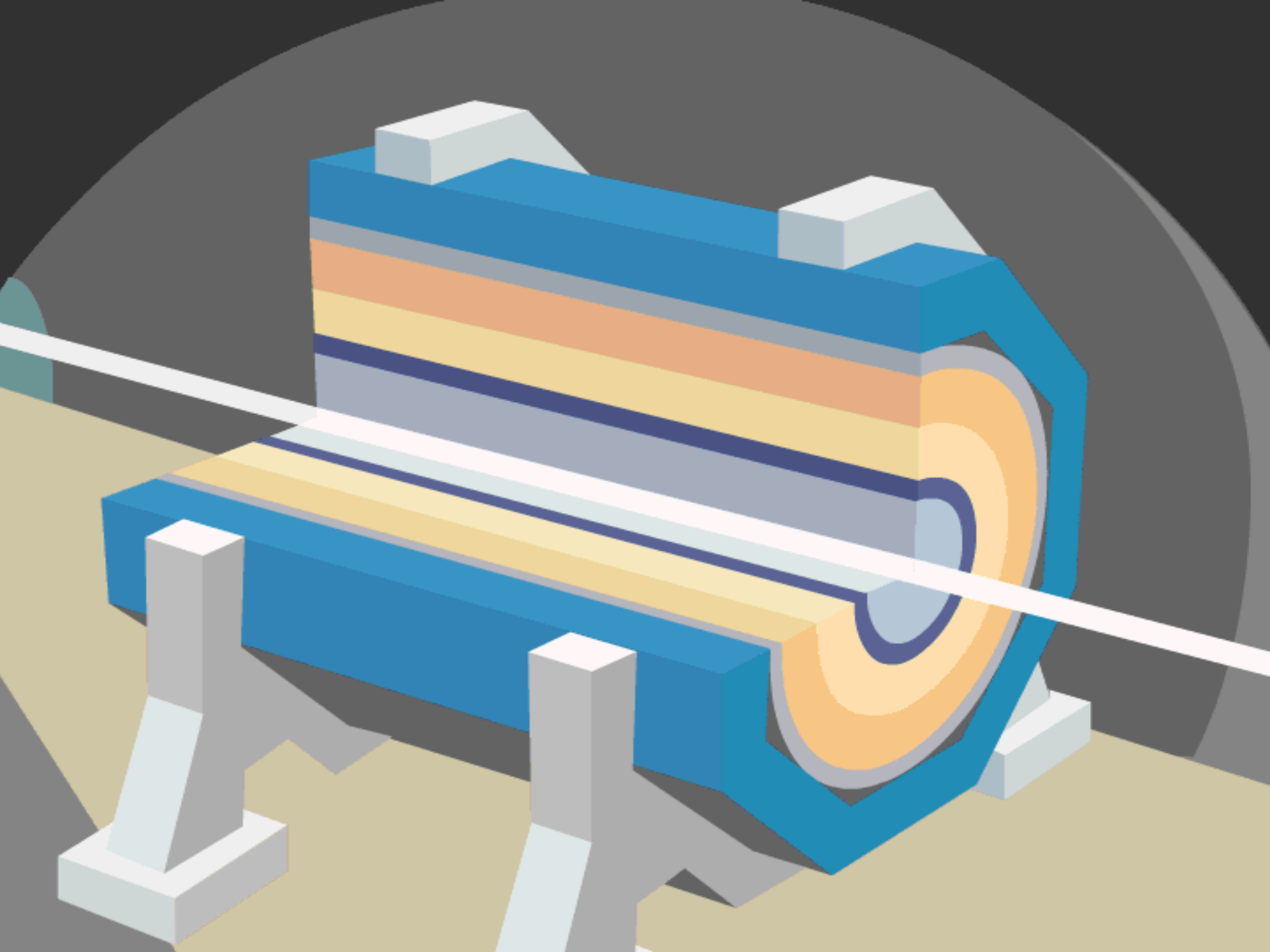


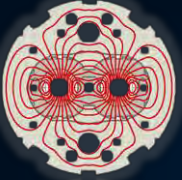
▶ p (proton)
▶ ion
▶ neutron

▶ \bar{p} (antiproton)
▶ 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 to Gran Sasso

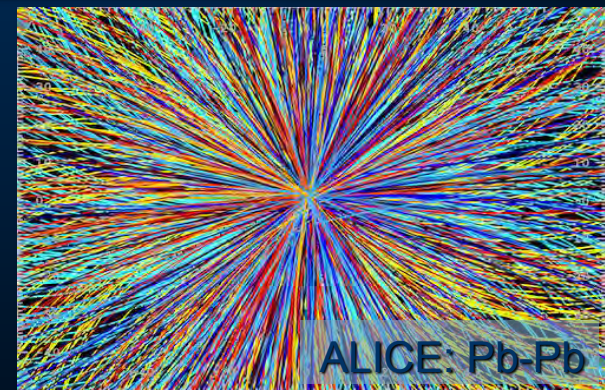
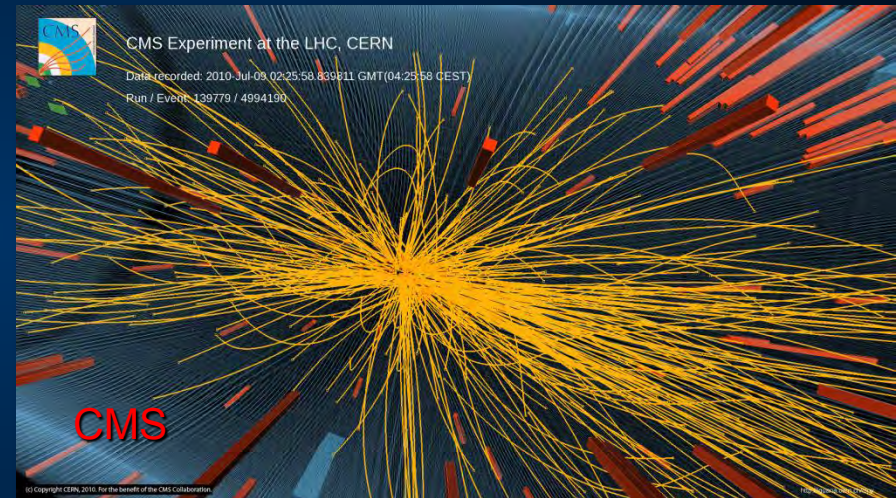
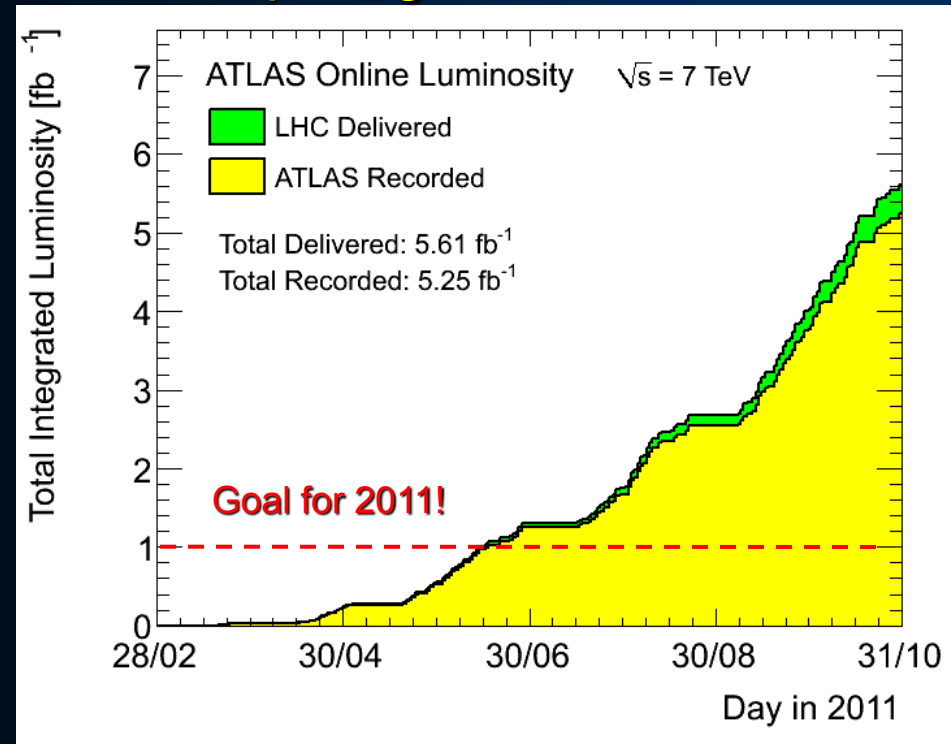




LHC + Experiments: spectacular start-up in 2010

First p-p collisions at $\sqrt{s} = 7$ TeV on 30 March 2010, restart 13 March 2011
Pb-Pb collisions at $\sqrt{s} = 2.76$ TeV/N at end of 2010 and 2011

→ Brilliant performances of LHC, experiments and GRID computing

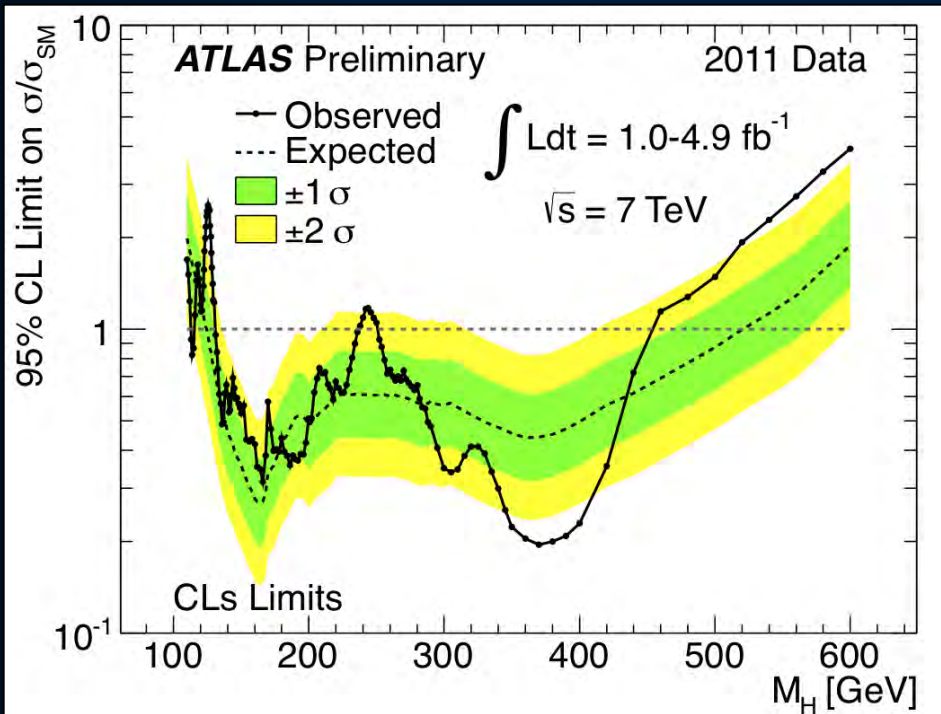


Impressive detector performances





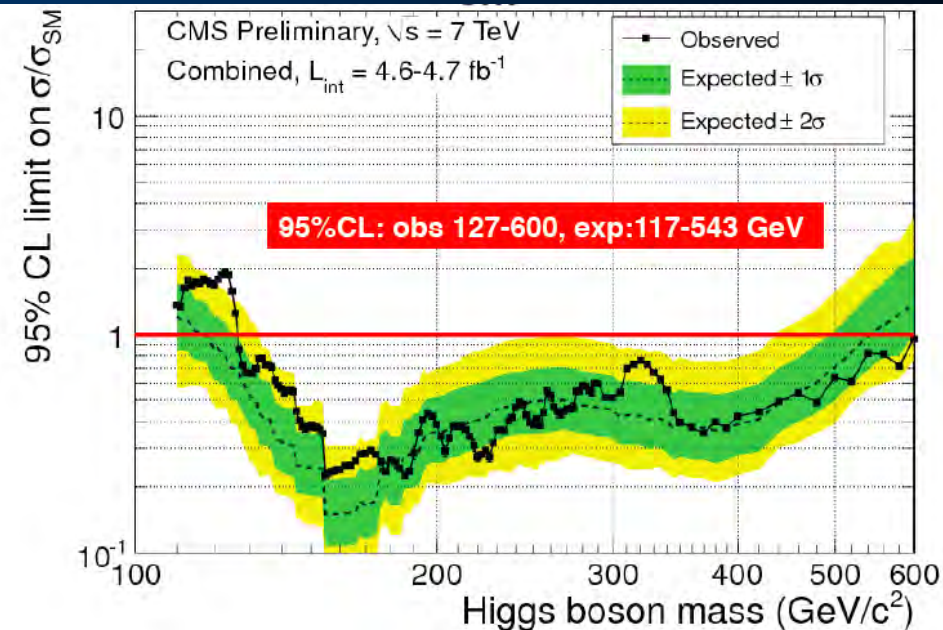
ATLAS and CMS results on Higgs search Seminar, 13 December 2011



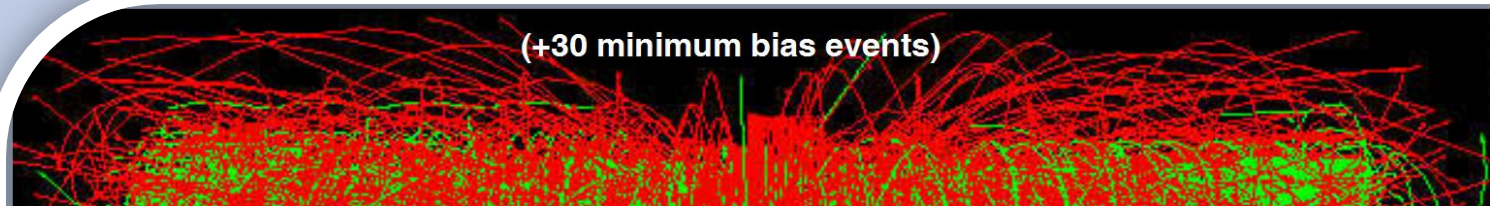
Excluded at 95% CL

CMS: $127 < m_H < 600$ GeV

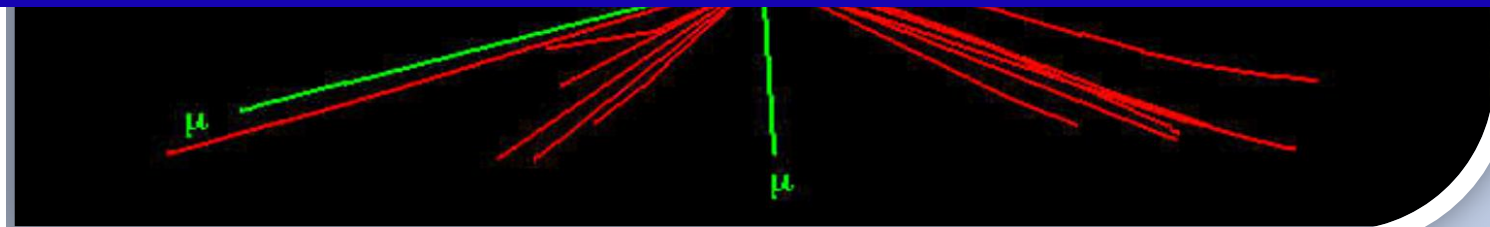
ATLAS: $112.7 < m_H < 115.5$ GeV
 $131 < m_H < 453$ GeV, except 237-251 GeV



❑ Searching for new particles requires selection and analysis of enormous quantity of data from LHC detectors



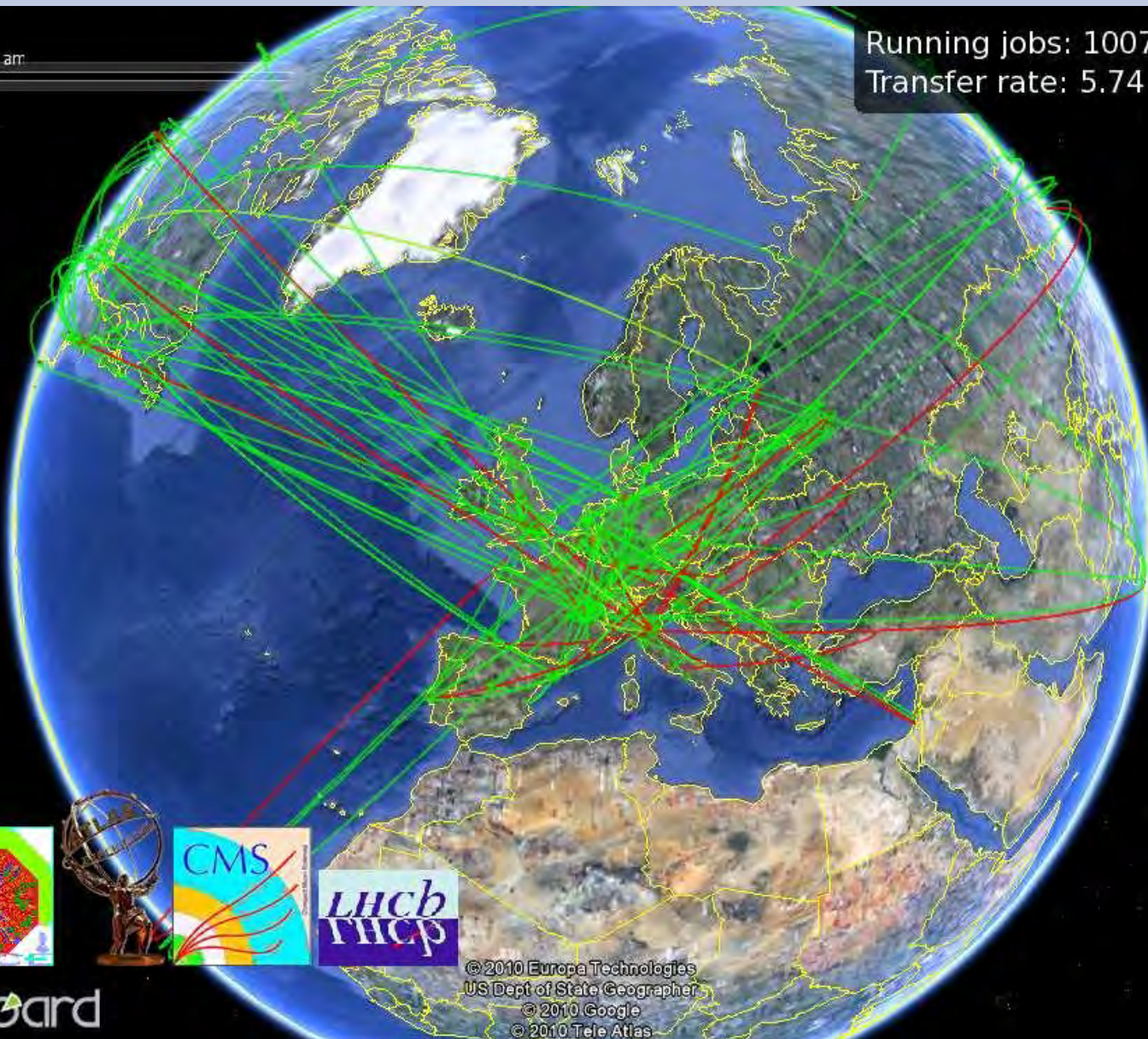
- LHC experiments produce **10-15 million Gigabytes** of data each year (about 20 million CDs!)
- LHC data analysis requires a computing power equivalent to **~100,000 of today's fastest PC processors.**



LCG-LHC Computing GRID

Oct 6, 2010 7:20:00 am

Running jobs: 100767.0
Transfer rate: 5.74 GiB/sec

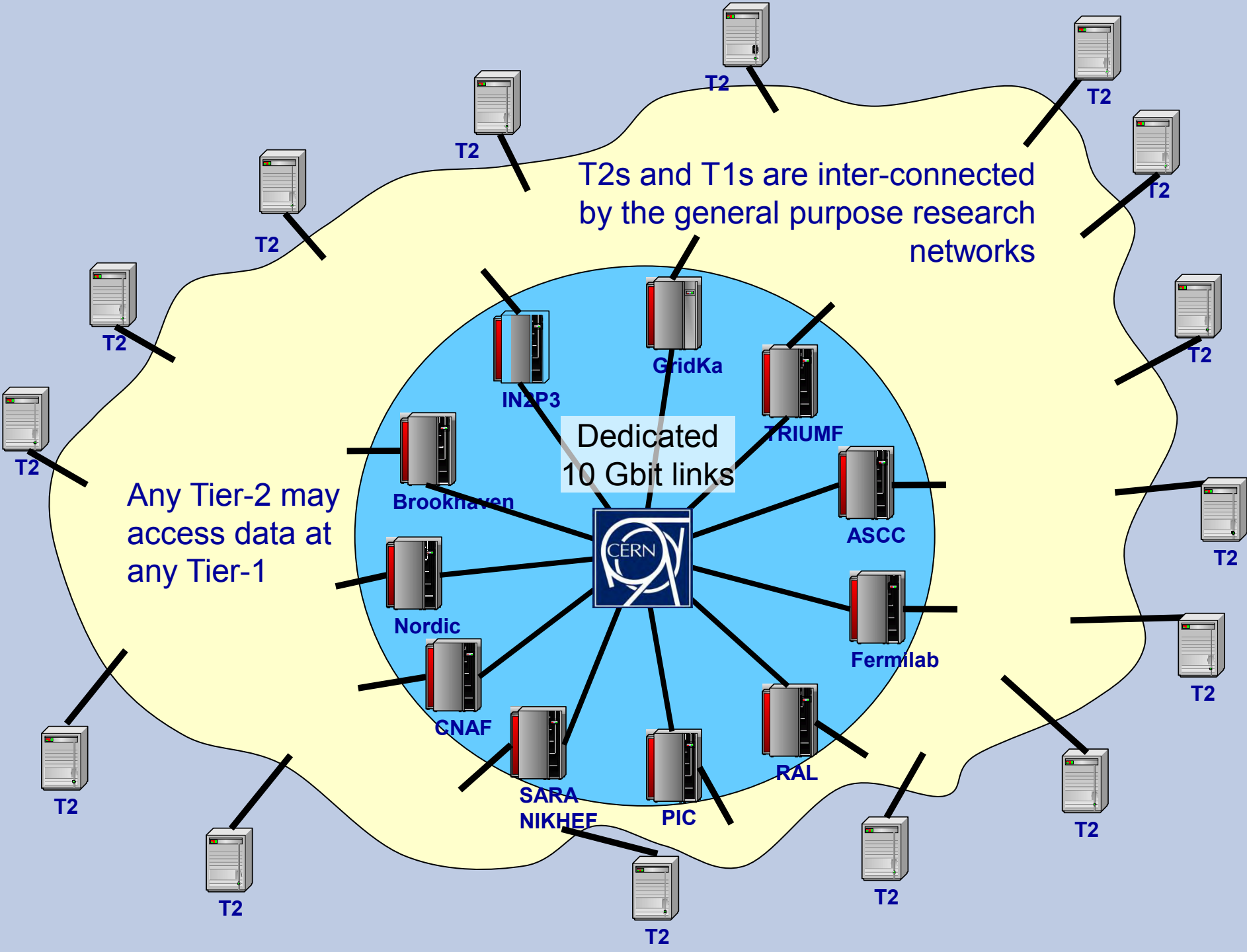


© 2010 Europa Technologies
US Dept of State Geographer
© 2010 Google
© 2010 Tele Atlas

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

©2010 Google

Eye alt 6720.01 mi



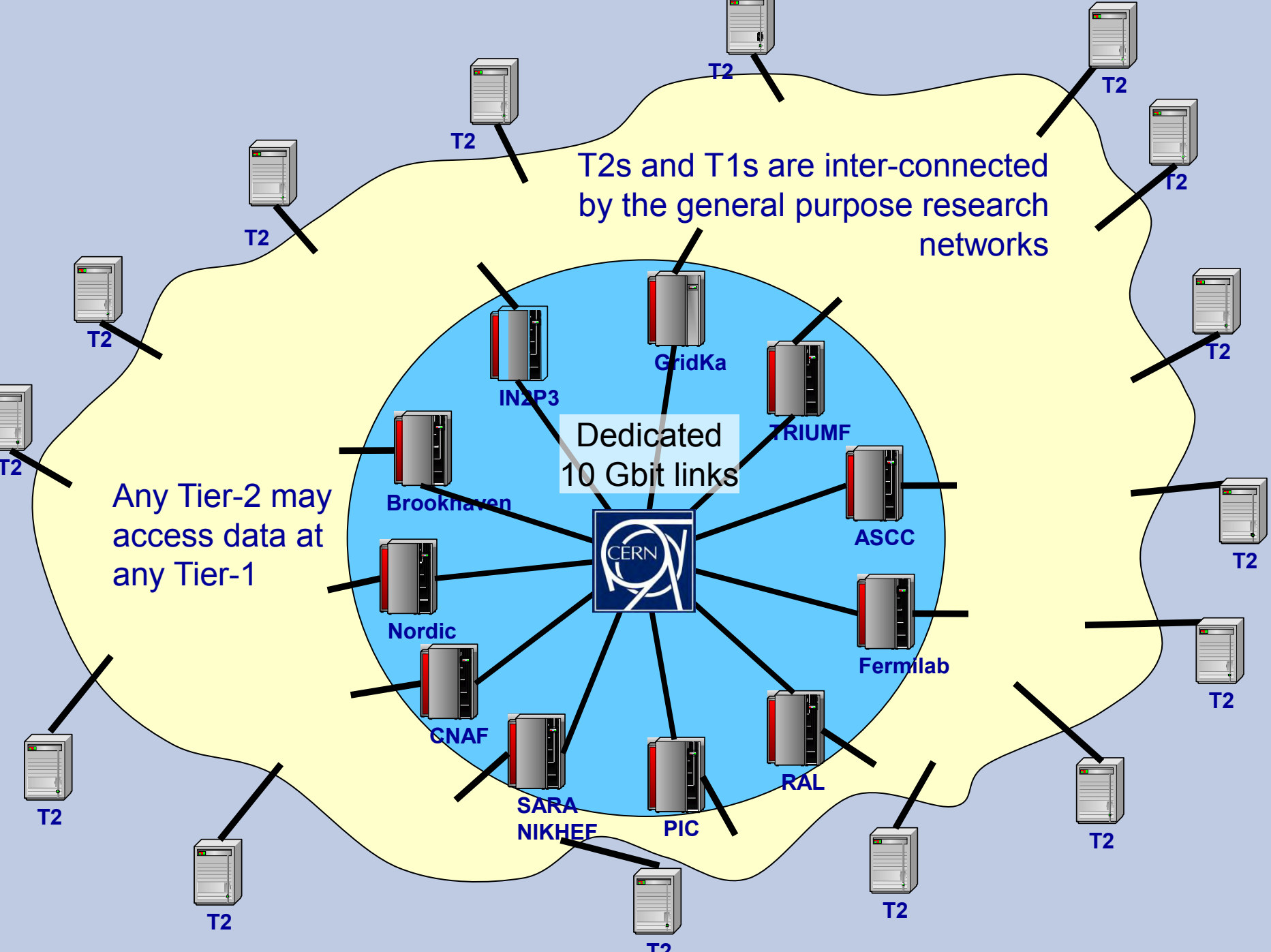
T2s and T1s are inter-connected by the general purpose research networks

Dedicated 10 Gbit links

Any Tier-2 may access data at any Tier-1



- Brookhaven
- IN2P3
- GridKa
- TRIUMF
- ASCC
- Fermilab
- RAL
- PIC
- NIKHEF
- SARA
- CNAF
- Nordic



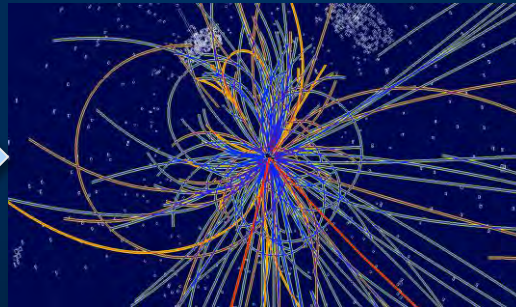


CERN: Particle Physics and Innovation

□ LHC – three main challenges



Accelerating particle beams



Detecting particles



Large-scale computing (Grid)



Three main challenges of the LHC Project

First: Construct a 2x7 TeV proton collider using existing tunnel of 27 km circumference (tunnel diameter 3.8 m).

Solution: Innovative design of superconducting magnets bending the beam to the tunnel radius, and cooled with superfluid helium.

Second: Construct detectors with unprecedented granularity, dimensions and rapidity of registration. **Solution:** Innovative detector types, new materials, giant superconducting magnets, fast electronics for events registration....**See other lectures**

Third: Develop a new computing system to handle and analyze enormous amount of data. . **Solution:** LCG – LHC Computing GRID – distributed computing concept.

ALL THE THREE REQUIRED GLOBAL COLLABORATION !

Participation of Non-Member States in CERN scientific programmes

- CERN is financed by **20 Member States**, with annual contributions proportional to the Net National Income (or GDP), but has scientific and educational links with nearly 100 countries!
- Non-Member States participate in financing selected Projects
- **Over 40 Non-Member States** participated in the LHC construction, providing around 1/6 th of its cost and over 3000 of physicists and engineers (over 1/3 of the total);

Contribution of CIS countries to LHC

(CIS - Содружество Независимых Государств, СНГ)

Important contribution of the Russian Federation

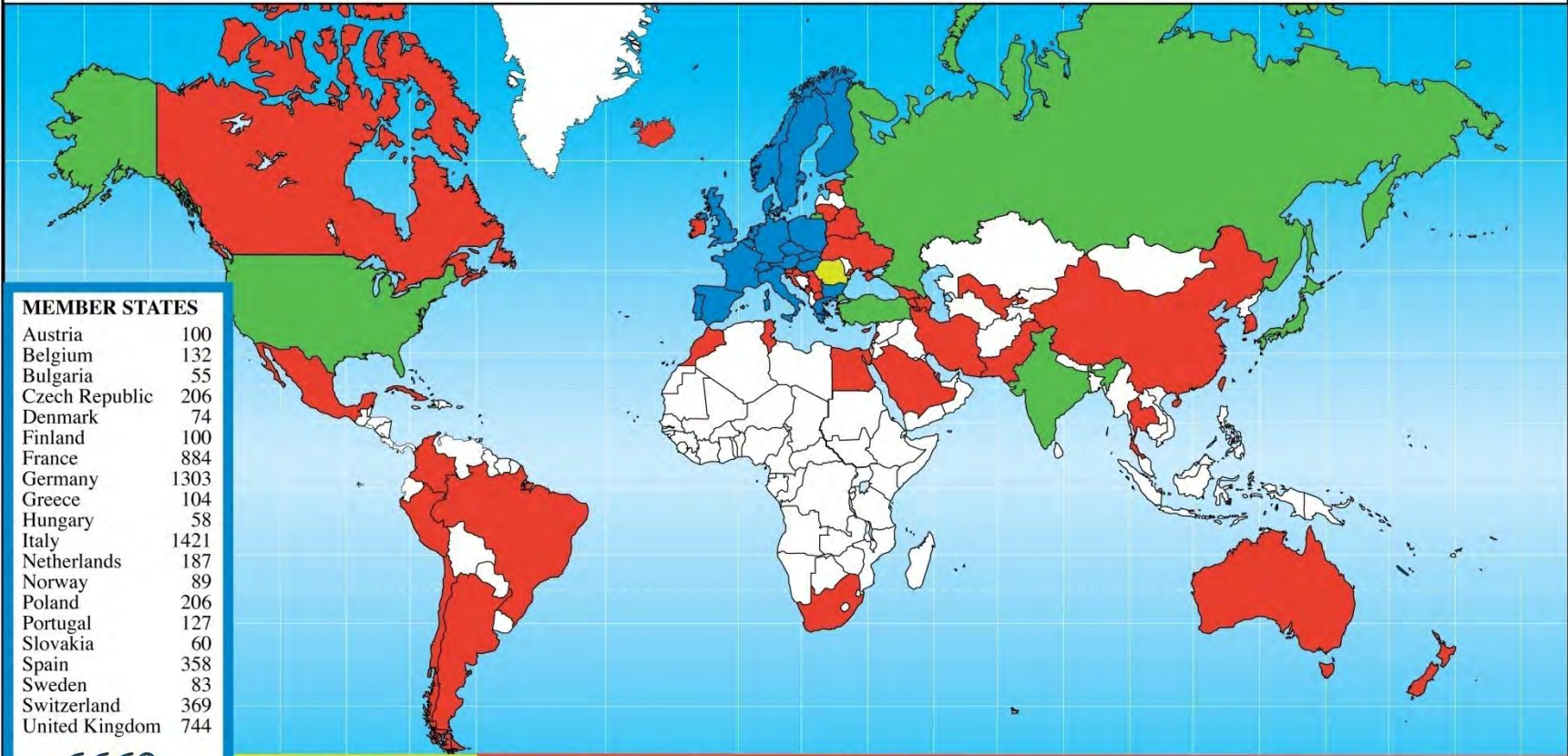
Highly appreciated contribution of other CIS countries.

Important role of JINR - Dubna in creating LHC collaborations with CIS countries →

**Armenia, Azerbaijan, Belarus, Georgia, Ukraine
(and also other JINR Members!)**

Science is getting more and more global

Distribution of All CERN Users by Nation of Institute on 9 January 2012



MEMBER STATES	
Austria	100
Belgium	132
Bulgaria	55
Czech Republic	206
Denmark	74
Finland	100
France	884
Germany	1303
Greece	104
Hungary	58
Italy	1421
Netherlands	187
Norway	89
Poland	206
Portugal	127
Slovakia	60
Spain	358
Sweden	83
Switzerland	369
United Kingdom	744

6660

OBSERVERS	
India	115
Japan	225
Russia	856
Turkey	77
USA	1708

2981

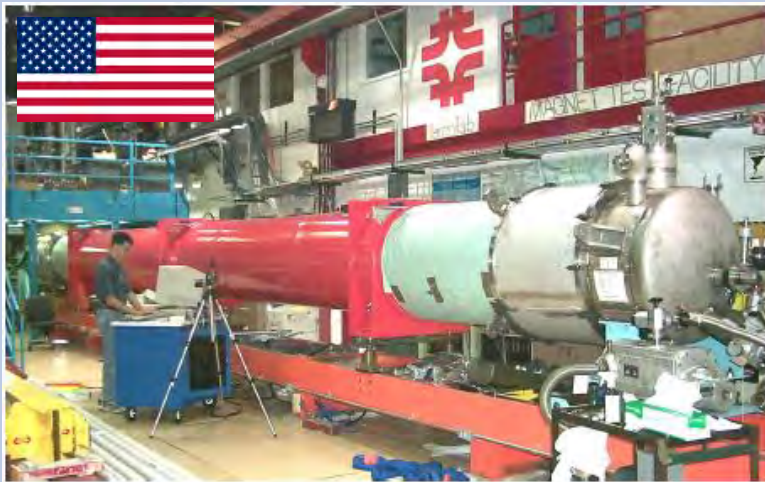
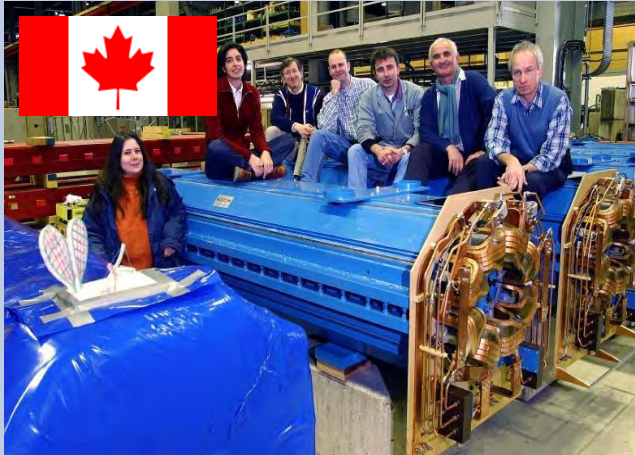
CANDIDATE FOR ACCESSION	
Romania	75

ASSOCIATE MEMBER IN THE PRE-STAGE TO MEMBERSHIP	
Israel	62

OTHERS	
China	95
China (Taipei)	67
Colombia	10
Croatia	17
Australia	24
Azerbaijan	1
Belarus	22
Brazil	93
Canada	167
Chile	4
Iran	14
Ireland	10
Korea	89
Lebanon	1
Lithuania	12
Malta	1
Mexico	43
Montenegro	1
Morocco	5
New Zealand	11
Pakistan	19
Peru	2
Qatar	1
Saudi Arabia	3
Serbia	26
Slovenia	37
South Africa	21
Thailand	5
T.F.Y.R.O.M.	2
Tunisia	1
Ukraine	21
Uzbekistan	1

907

LHC Machine - Vital Contribution of Non-Member States: Canada, India, Japan, Russia, US





Ukraine and CERN



- ❑ International Cooperation Agreement (ICA-UA-0055) signed in April 1993
- ❑ Involvement in the experiments
LHC: **ALICE, CMS** and **LHCb**
non-LHC: **OPERA**
- ❑ **Grid technology** is developing fast in Ukraine, thanks to the support of the Academy of Sciences, which signed in 2006 the MoU for WLCG
- ❑ Ukrainian interest in collaboration on **accelerator R&D**, with a developing involvement in the R&D for CLIC/CTF3





Ukraine and CERN



Contributions to the ALICE experiment

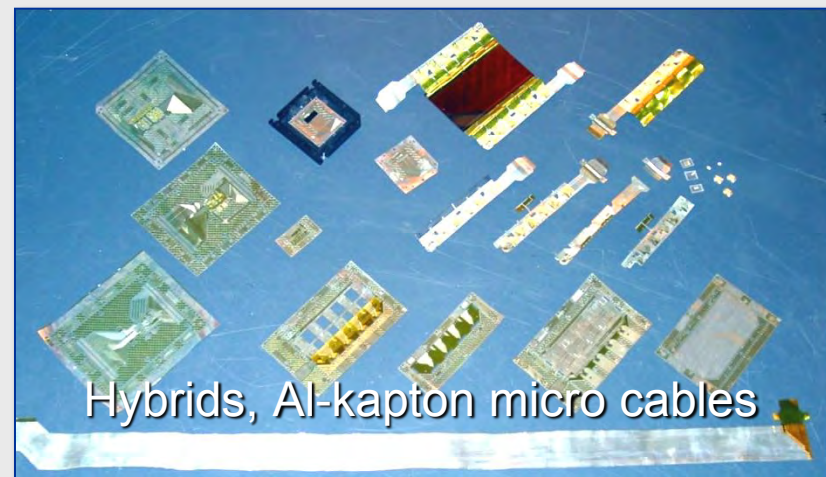


- ❑ Contributions mainly to ITS
- ❑ Physics analysis and computing
200 nodes in three centers with TIER2-functionality

3 Institutes

- ❑ Kharkov Institute of Physics and Technology, Kharkov
- ❑ Scientific Research Technological Institute of Instrument Engineering, Kharkov
- ❑ Bogolyubov Institute for Theoretical Physics, Kiev

~10 members



Hybrids, Al-kapton micro cables





Ukraine and CERN



Contributions to the LHCb experiment

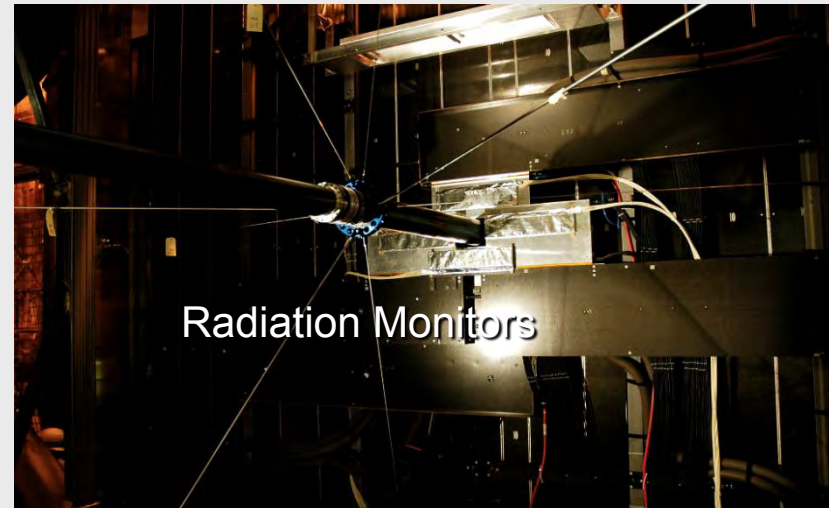
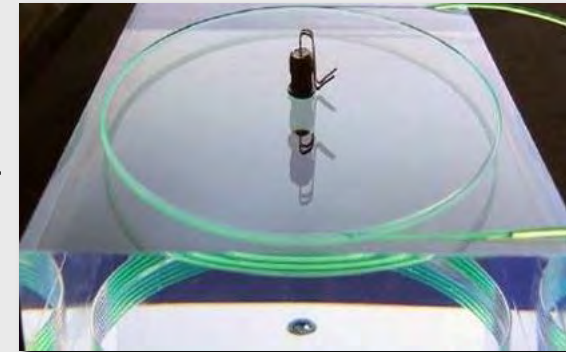


LHCb

2 Institutes

- Kharkov, IPT
 - Kiev, INR
- ≈7 members

Preshower Detector (part of calorimeter)



Radiation Monitors

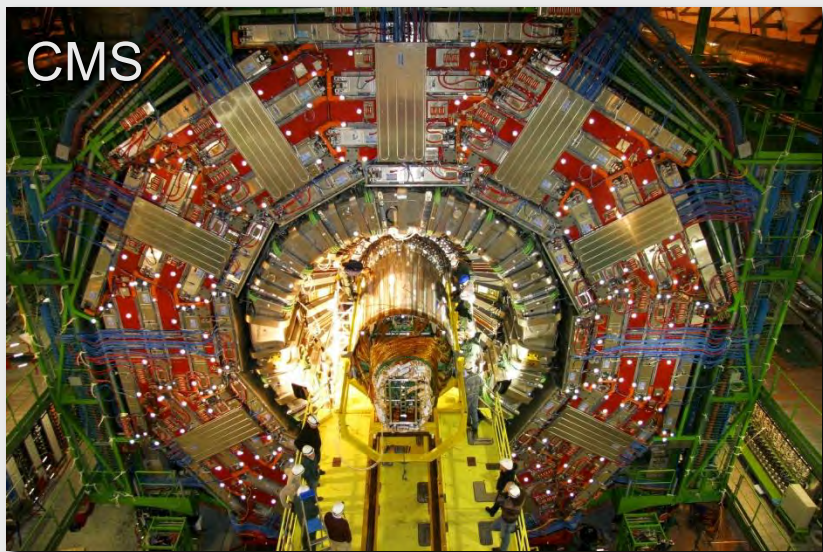




Ukraine and CERN



Contributions to the CMS experiment

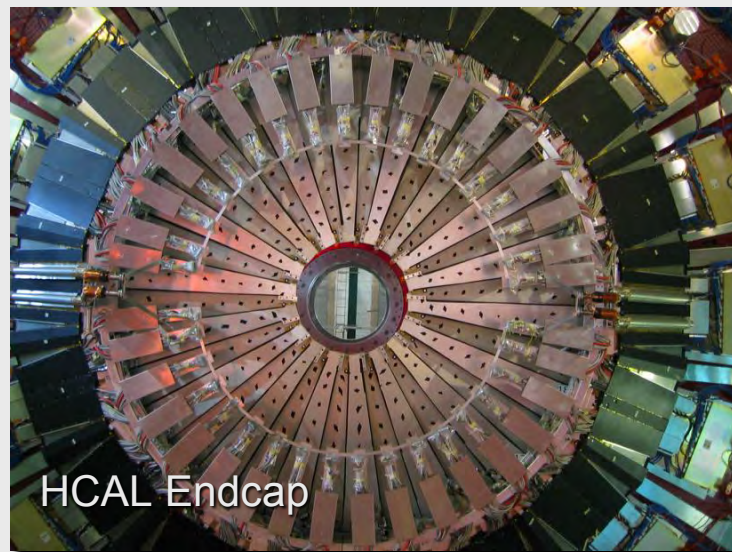


- Contributed to design, manufacture and calibration of **Scintillation Tiles of Endcap Hadron Calorimeters**
- Development of **CMS Physics program**

3 Institutes participate in the framework of the Russia and Dubna Member States – RDMS CMS Collaboration, **since 1992**

- National Scientific Center, Kharkov Institute of Physics and Technology
- Institute of Single Crystals of National Academy of Science
- Kharkov State University

~15 members

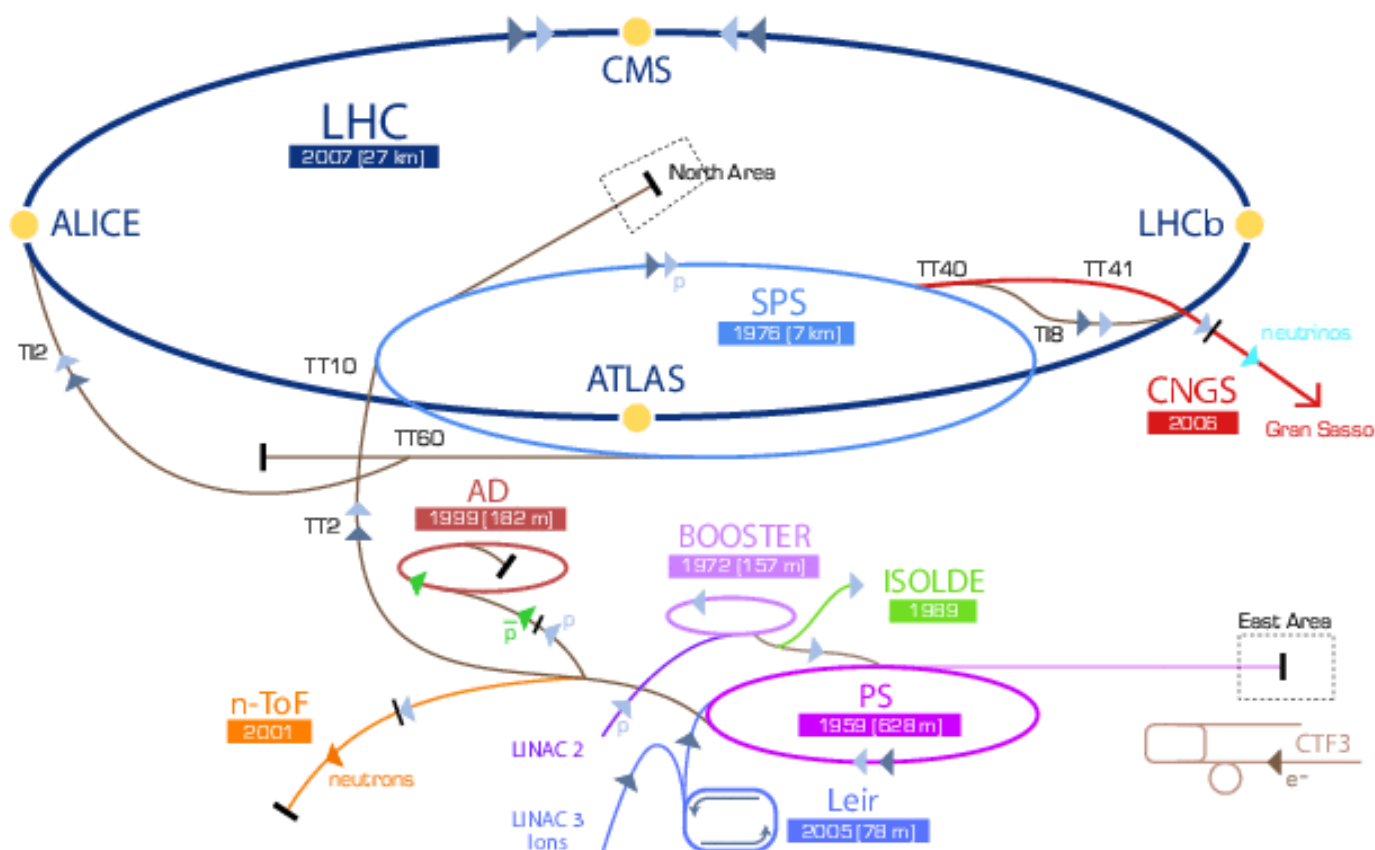


SCINTILLATING CRYSTALS for CMS

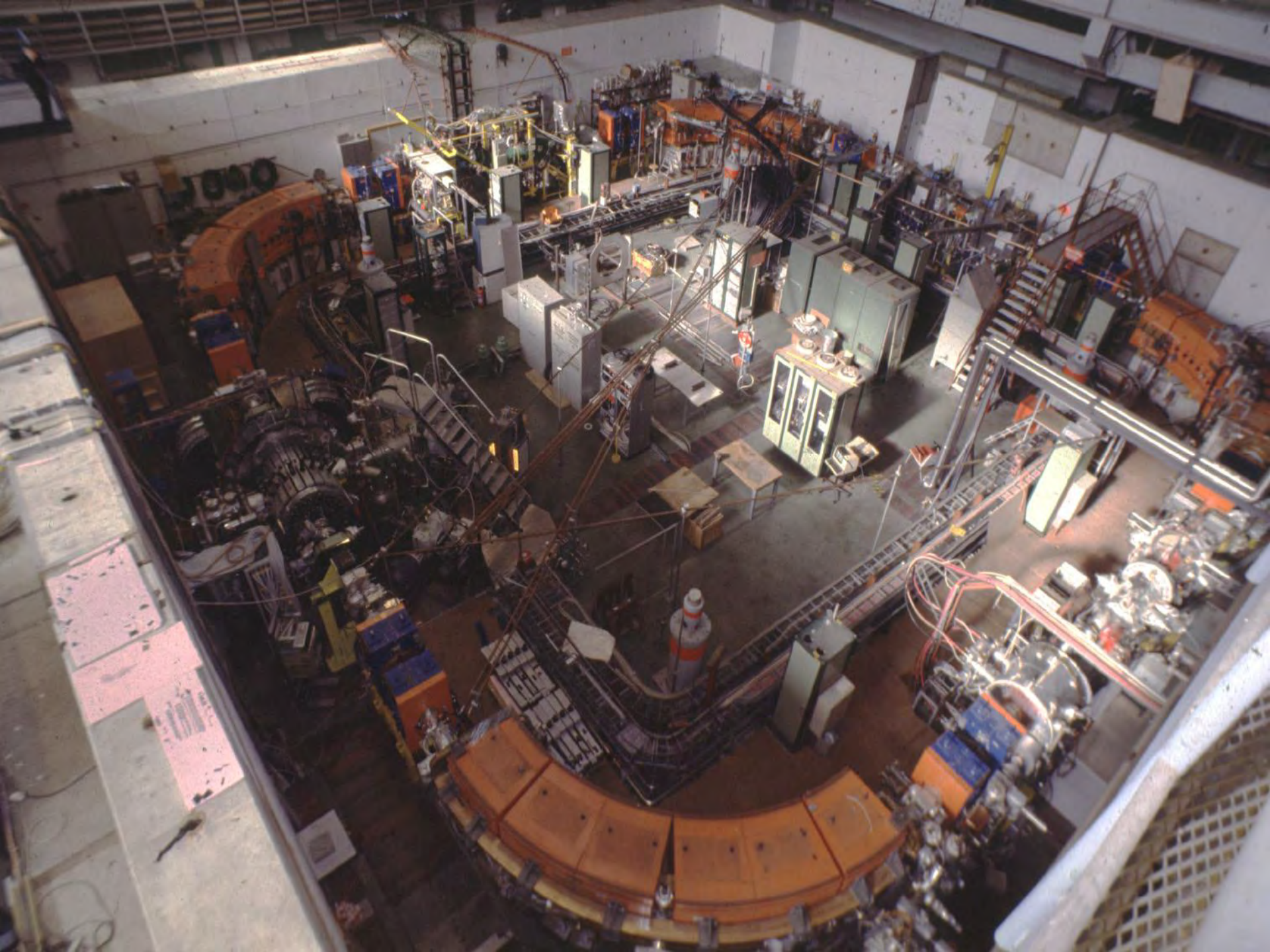
Monocrystals of PbWO_4 first **developed in Ukraine** and then produced in Russia – one of the main elements of CMS detector

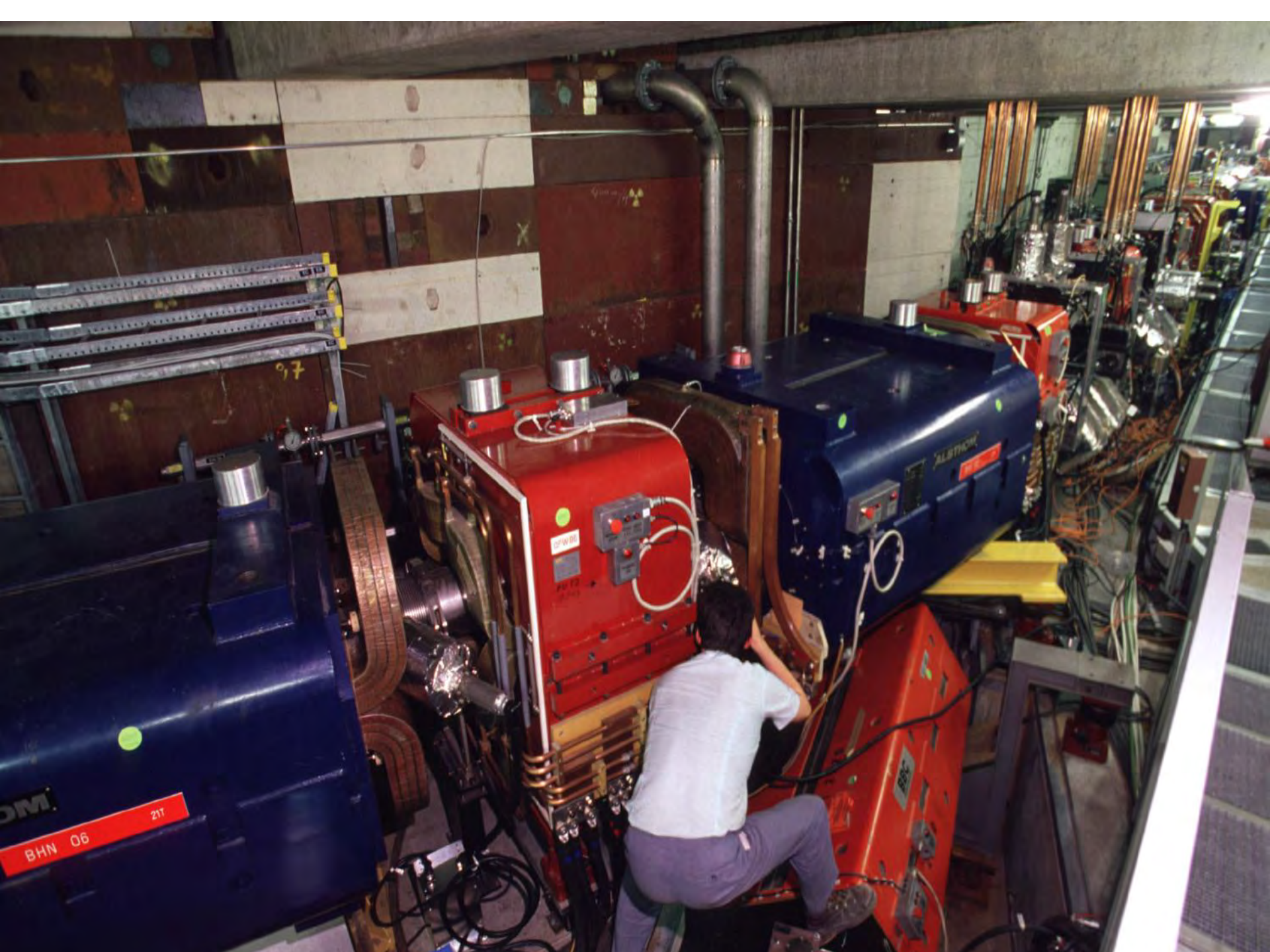


CERN – world biggest accelerator complex



▶ p (proton) ▶ ion ▶ neutrons ▶ \bar{p} (antiproton) ▶ \rightarrow proton/antiproton conversion ▶ neutrinos ▶ electron



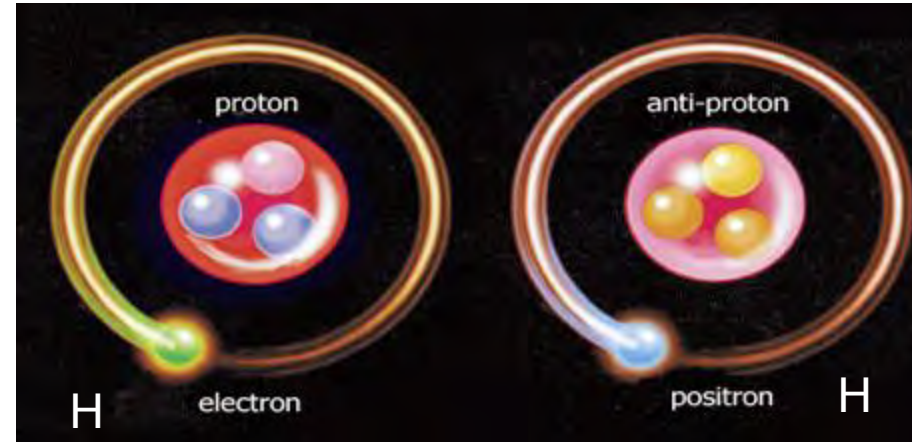


Antimatter Physics

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 !

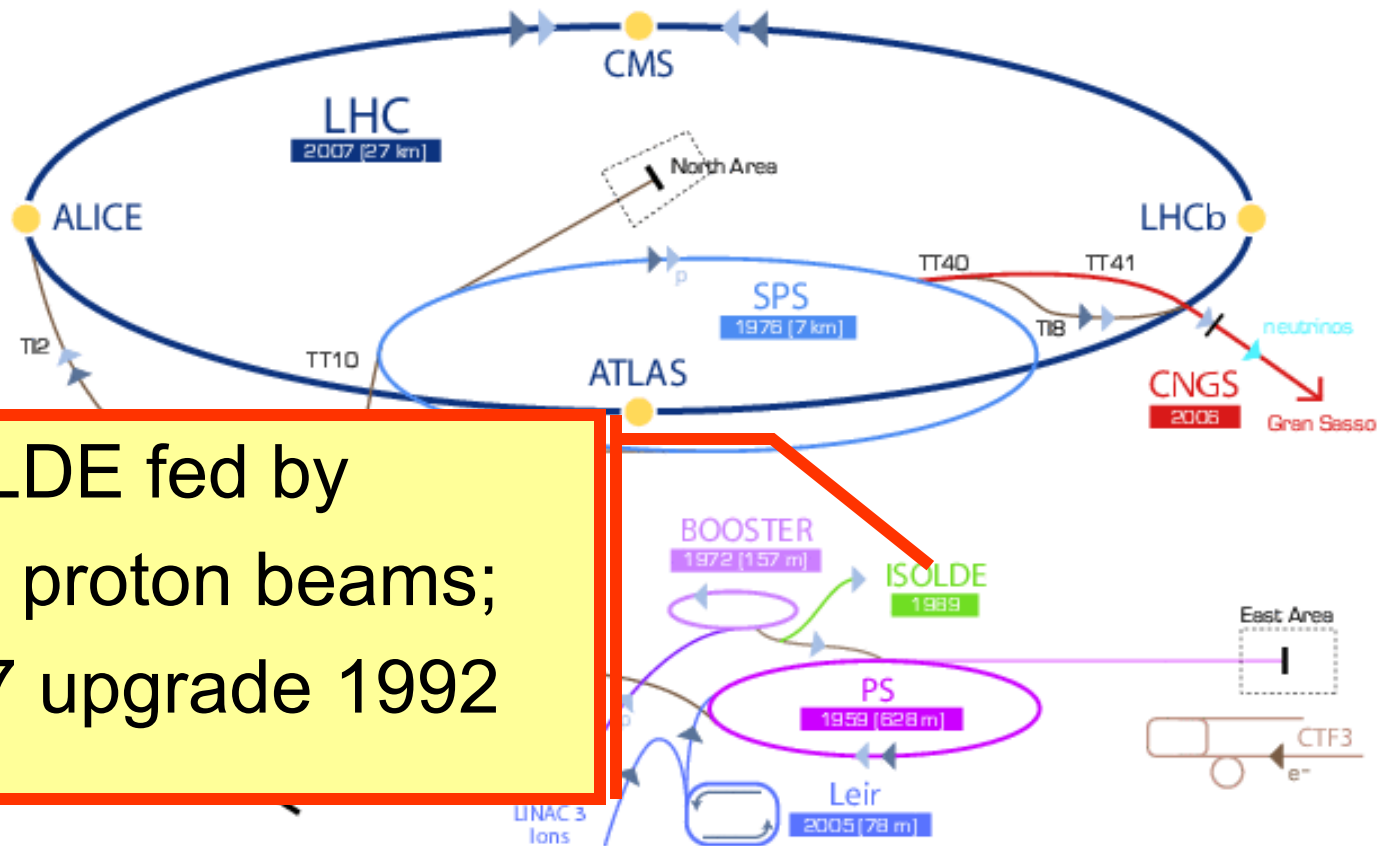


ACE

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



CERN accelerator complex, working not only for LHC



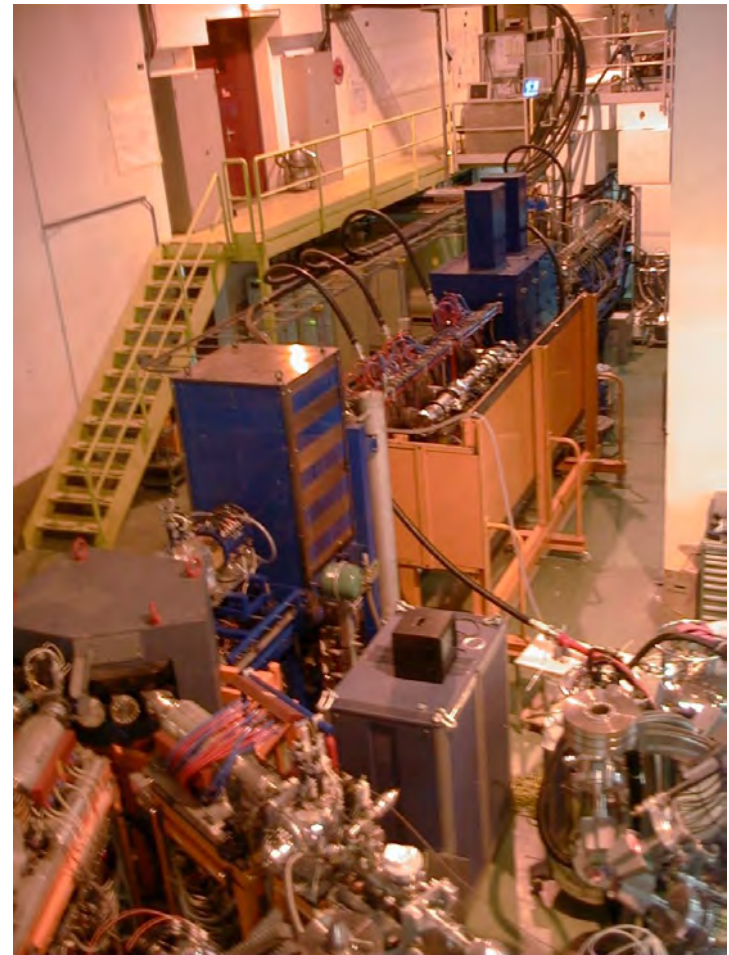
ISOLDE fed by
PSB proton beams;
1967 upgrade 1992

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

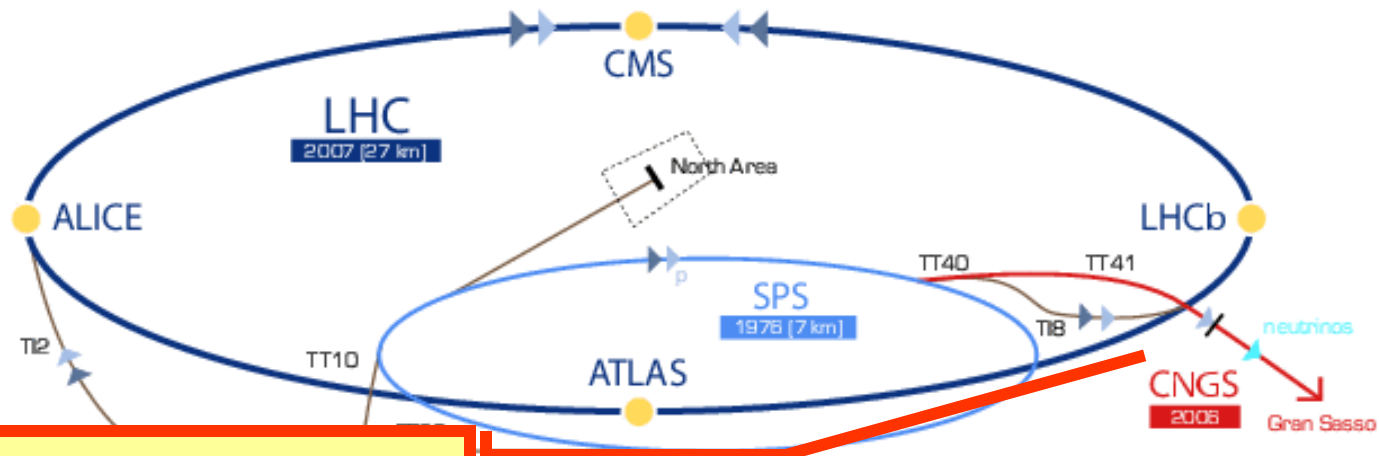
ISOLDE - Isotope Separator On Line, and Radioactive beam EXperiment (REX)

An alchemical factory for nuclear physics

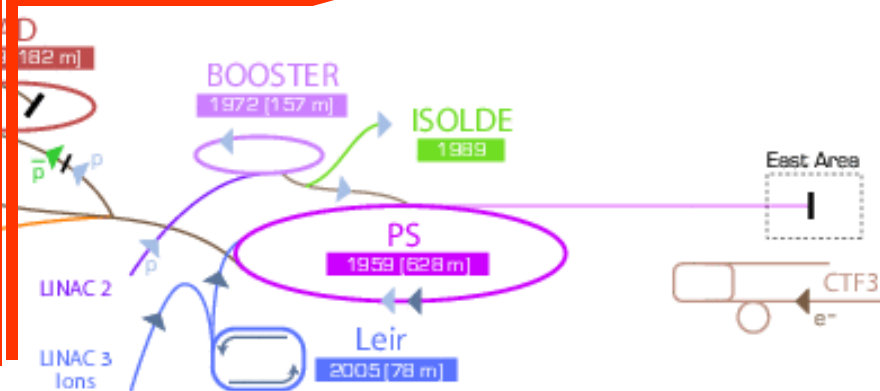
Low-energy beams of radioactive isotopes - atomic nuclei. The facility, located at the Proton-Synchrotron Booster (PSB), is like a small alchemical factory, changing one element to another. It produces a total of more than 1000 different isotopes for a wide range of research.



CERN accelerator complex, working not only for LHC !



CNGS fed by
SPS proton beams

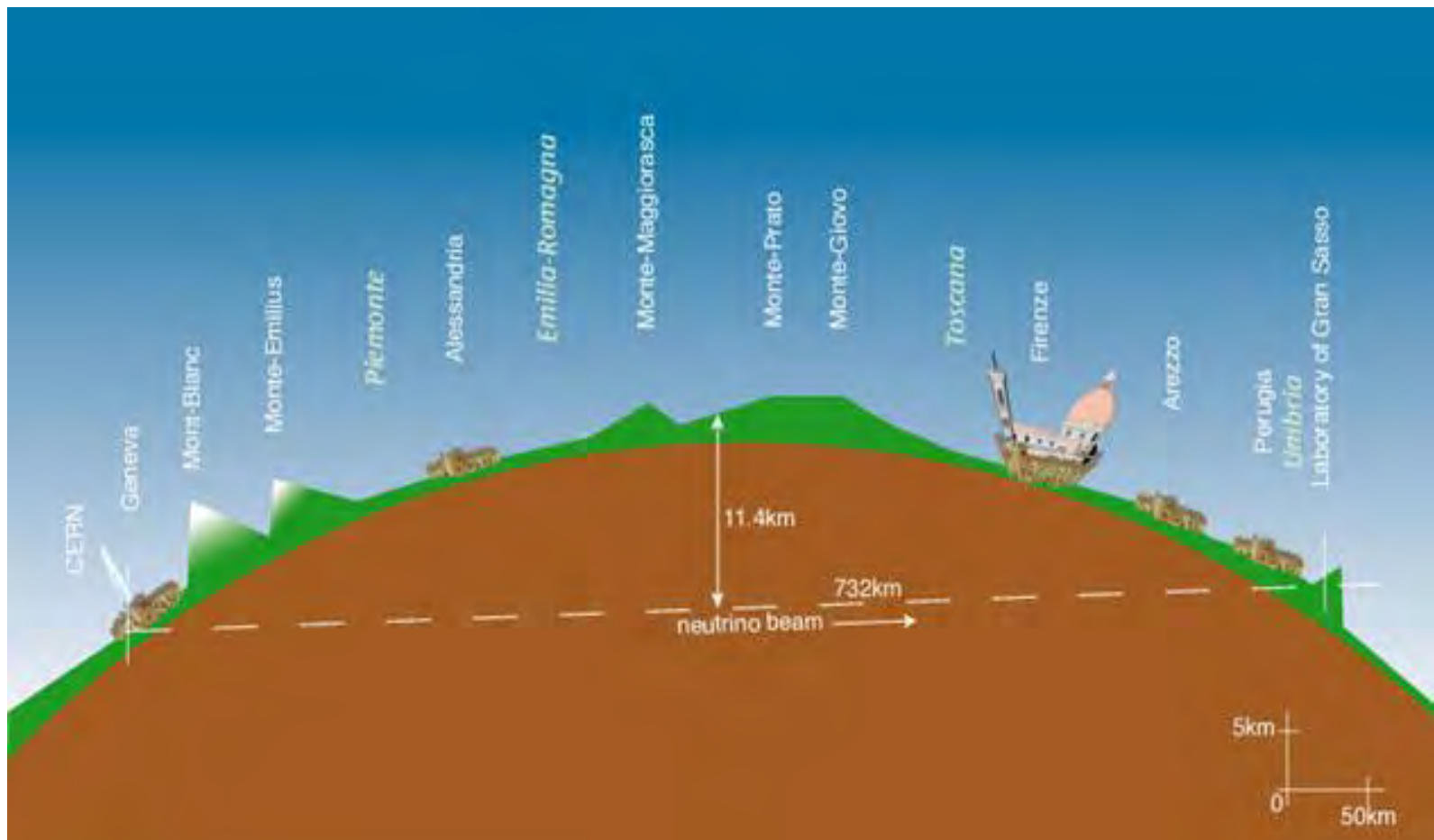


▶ p (proton) ▶ ion ▶ neutrons ▶ \bar{p} (antiproton) ▶ \leftrightarrow proton/antiproton conversion ▶ neutrinos ▶ electron

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.



Study effect of cosmic rays on clouds formation
(cosmic rays “simulated “ by T11 beam, clouds
created in a large climatic chamber





Technologies and Innovations - spin-off from HEP research

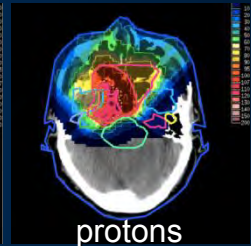
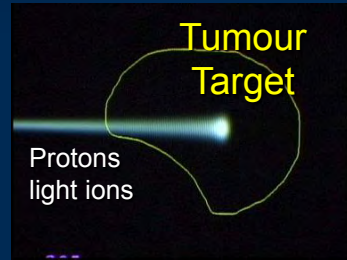
Example: Medical applications

Combining Physics, IT, Biology and Medicine to fight cancer

Hadron Therapy

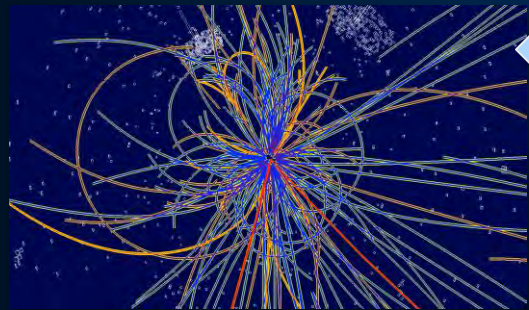


Accelerating particle beams
~30'000 accelerators worldwide
~17'000 used for medicine



>70'000 patients treated worldwide (30 facilities)
>21'000 patients treated in Europe (9 facilities)

Leadership in Ion Beam Therapy now in Europe and Japan



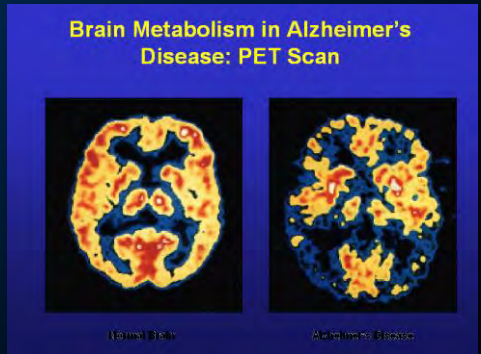
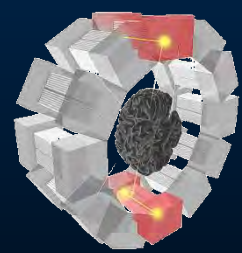
Detecting particles

Imaging

Clinical trial in Portugal for new breast imaging system (ClearPEM)



PET Scanner



Educational opportunities at CERN





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





CERN Training Programmes

Senior Scientists-Physicists
Associate Programme

**Young Researchers in
Physics/Engineering/Computing**
Fellowship Programme
**CERN SCHOOLS of Physics / Accelerators /
Computing**

Student Programmes
Technical Students
Doctoral Students
Administrative Students

Physics Students
Summer Students
Programme



CERN Teacher Schools
International and National
Programmes



Training Programmes for Students at CERN

- **Summer Student Programme** for undergraduate students, mainly in physics, but also engineering or computing; 8 weeks at CERN, after the 3rd year of studies.
- **Technical Student Programme** for undergraduate students in applied physics, engineering or computing; training period of 4 to 12 months during the course of their studies.
- **Administrative Student Programme** for undergraduate students in administration: training period of 2 to 12 months during the course of their studies.
- **Doctoral Student Programme** for postgraduate students preparing a doctoral thesis in applied physics, engineering or computing to spend between 12 to 36 months at CERN.

Teacher Programmes at CERN

What for?

Raise interest of young people in modern science, physics, particle physics physics

How?

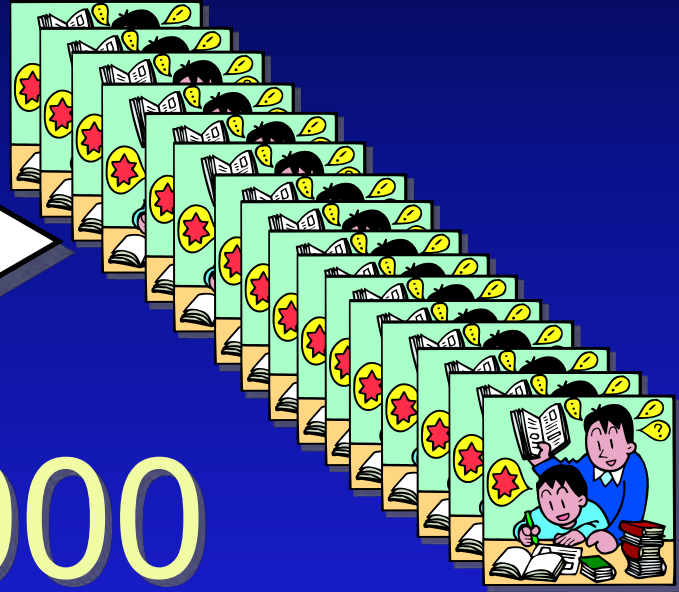
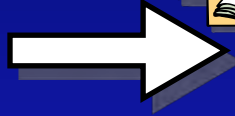
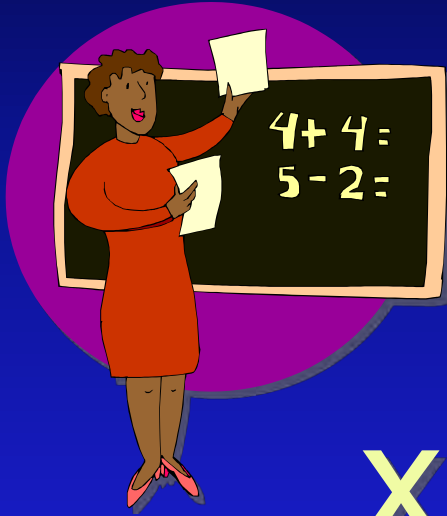
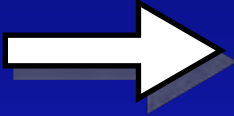
Introduce modern science topics in classrooms

Why teachers?

Because.....-->



Looking for multiplicative factors



x 1000

School Teacher

School Students

CERN teacher programmes

- **International “High School Teacher” school (3 weeks)**

Fully funded by CERN for MS participants (programme, travel, accommodation). Participants from US, Asia, South America, Africa funded externally. **In English - 2009: 120 applications from 38 countries**

- **International Weekend school (3 days, 2 per year)**

Partially funded by CERN for MS participants
(programme, travel, accommodation). **In English**

- **National schools (1 week) - 20-25 courses per year**

In mother tongue (speakers from the national science community). External funding of travel, accommodation.

Create teaching resources in national language - important for classroom activities. Build networks between teachers and with scientists inside country



What are we trying to achieve with the help of physics teachers ?

1: RAISE AND MAINTAIN THE INTEREST OF STUDENTS IN MODERN SCIENCE

Motivate them to continue scientific education at school
Help them to better understand the physical world

Improve scientific literacy

2: INSTIL A FEELING OF MYSTERY AND DISCOVERY POTENTIAL

Motivate students to take up physics at universities

**Prepare the future generation of physicists
and engineers**

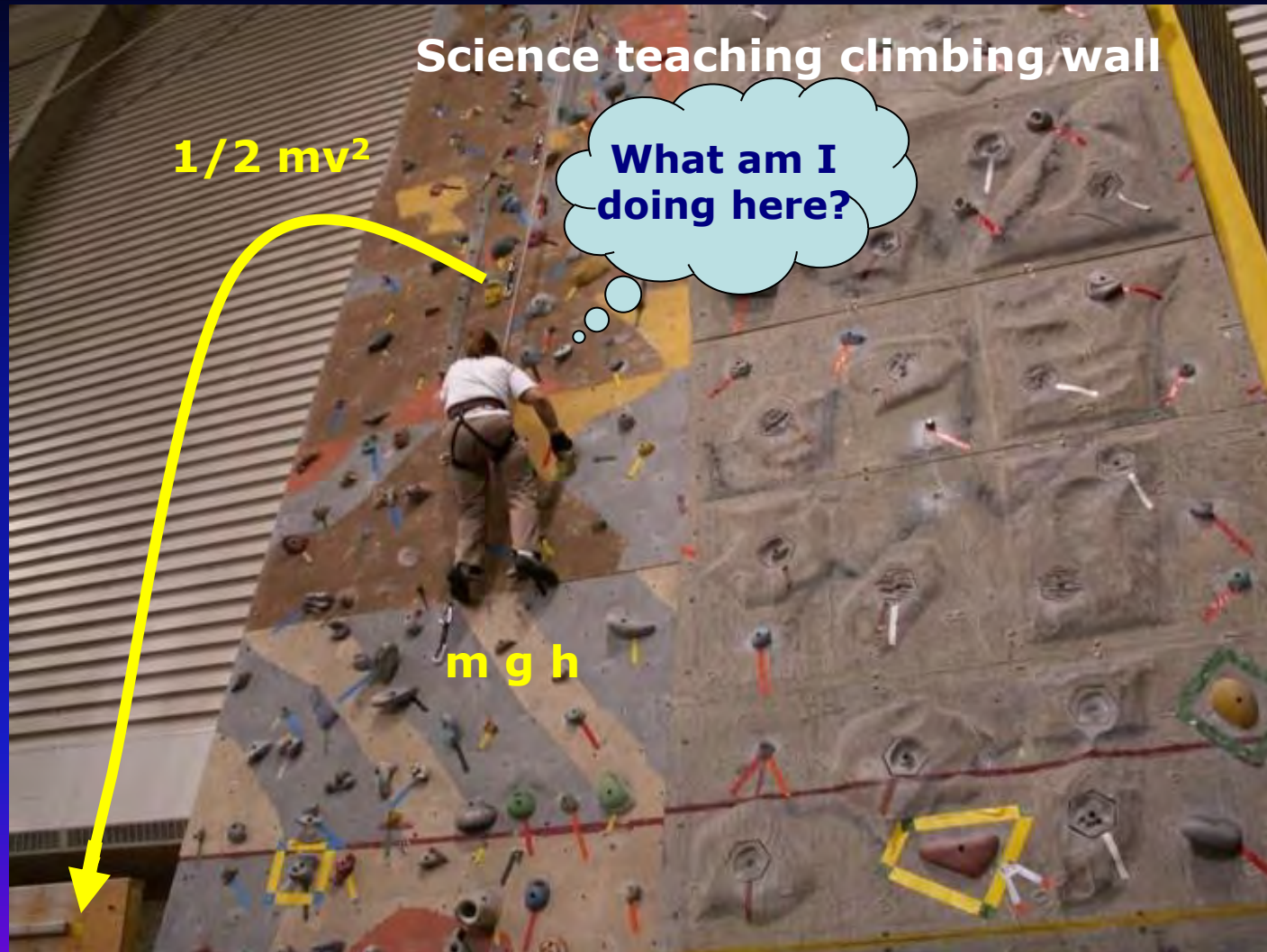
SCIENCE IS ALIVE !



How researchers view science



How school students view science





Take students on a sight-seeing tour ...



Link modern physics to school curriculum

Content of Teacher Programmes

- **Lectures**

- Introductions to CERN
- Particle Physics
- Cosmology
- LHC Experiments
- Particle Accelerators
- Medical Applications of Particle Physics
- GRID

- **Visits to experimental facilities**

- **Meet physicists in a variety of informal settings**

- **Hands-on activities : TEACHER'S LAB**

- All lectures are recorded, archived, and publicly available
- Very positive feedback
- But what happens afterwards ... ?



Cathode ray tube

- documentation: [pdf](#) | [doc](#)
- quick reference guide: [pdf](#) | [doc](#)



Electron diffraction tube

- documentation: [pdf](#) | [doc](#)
- quick reference guide: [pdf](#) | [doc](#)



Fine beam tube

- documentation: [pdf](#) | [doc](#)
- quick reference guide: [pdf](#) | [doc](#)



Photoelectric effect

- documentation: [pdf](#) | [doc](#)
- quick reference guide: [pdf](#) | [doc](#)



Electron spin resonance

- documentation: [pdf](#) | [doc](#)
- quick reference guide: [pdf](#) | [doc](#)

You are invited to:

1. Participate in the Teacher Programme at CERN;
2. Use educational resources of CERN;
3. Organize a Video-Conference between CERN and your school;
4. Inform your students about educational opportunities at CERN.
5. Come to CERN with your students for a one-day visit (Extended School visits);

2 Educational resources for schools

Lesson Plans for teaching modern science in schools (14-15 year olds)

First module: ANTIMATTER, available on 'Education' website

<p>Living In the ANTI-Material World</p>	<table border="1"><tr><td></td></tr><tr><td>Knowing Anti-Me, Knowing Anti-You</td></tr><tr><td></td></tr></table>		Knowing Anti-Me, Knowing Anti-You		<p>Operation: Annihilate!</p> <p>APPLE → KABOOM!!! ← ANTI-APPLE</p>
Knowing Anti-Me, Knowing Anti-You					
<p>? <i>The</i> Mother <i>Of All</i> Conundrums ?</p>	<p>Dammit Jim, I'm a DOCTOR, not a PARTICLE PHYSICIST!</p> <p>MEDICINE THE NEXT GENERATION</p>	<p>ENERGY'S SPAWN</p>			
<p>IT CAME FROM OUTER SPACE</p>	<p>Boys With Toys</p>				

Posters: Evolution of the Universe



On 17 posters:

Key concepts of the evolution of matter and the Universe

back to the Big Bang and the questions that LHC will address





Video-Conferences between CERN and schools:

(with Europe, US, Asia, and Africa)

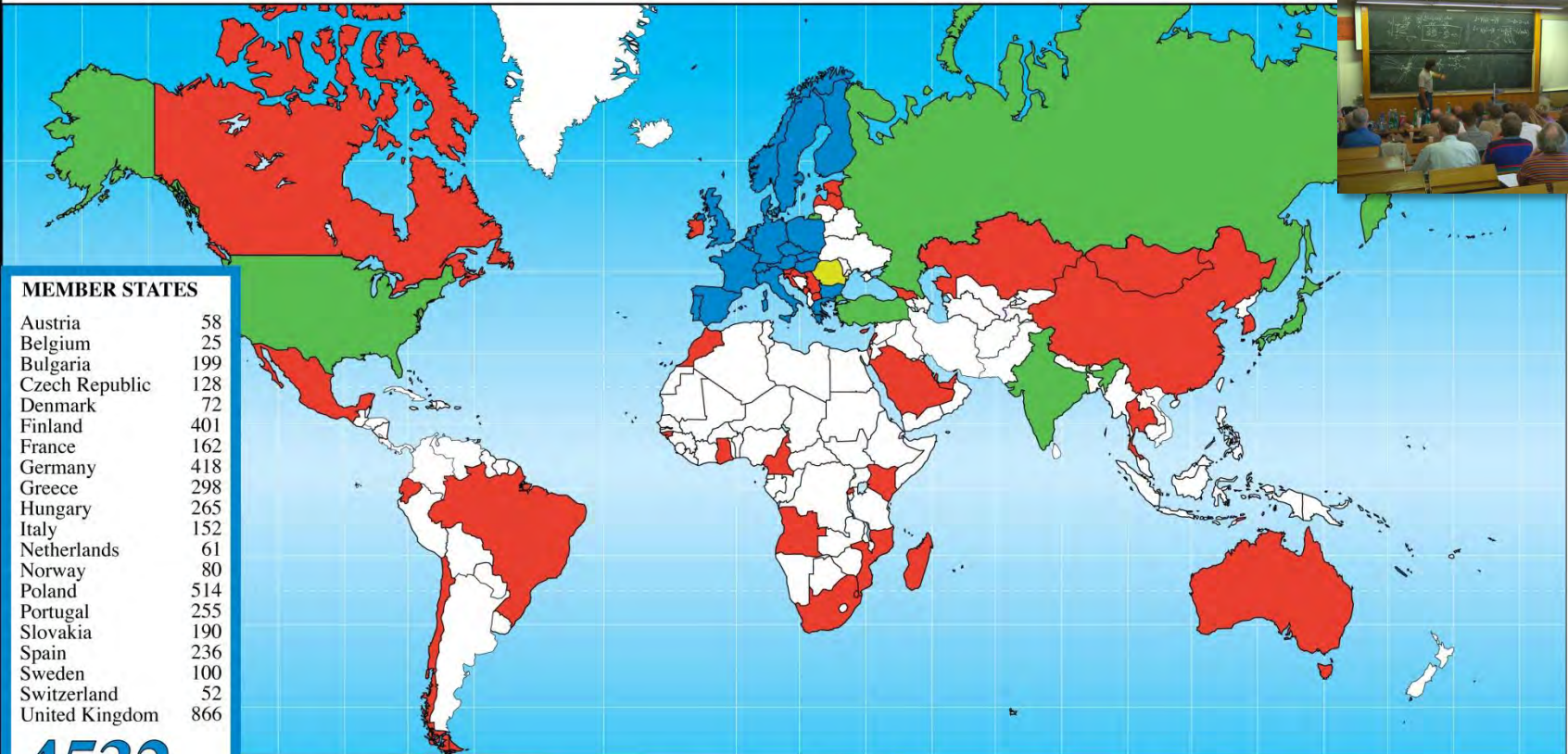
BEST: via high speed Internet (plus
Polycom/Tandberg)

o.k. with **EVO**, Skype, etc.



CERN Teacher Programme

CERN Teacher Programme Participants 1998 - 2011



MEMBER STATES	
Austria	58
Belgium	25
Bulgaria	199
Czech Republic	128
Denmark	72
Finland	401
France	162
Germany	418
Greece	298
Hungary	265
Italy	152
Netherlands	61
Norway	80
Poland	514
Portugal	255
Slovakia	190
Spain	236
Sweden	100
Switzerland	52
United Kingdom	866

4532

CANDIDATE FOR ACCESSION	
Romania	10

ASSOCIATE MEMBER IN THE PRE-STAGE TO MEMBERSHIP	
Israel	2

OBSERVER STATES	
India	2
Japan	3
Russia	132
Turkey	3
USA	56

196

OTHERS			
Angola	4	China	1
Australia	3	Croatia	1
Azerbaijan	1	Cyprus	4
Brazil	53	Ecuador	1
Cameroon	1	Estonia	18
Canada	1	Georgia	16
Chile	3	Ghana	4
		Guinea Bissau	1
		Ireland	3
		Kazakhstan	3
		Kenya	2
		Latvia	1
		Lebanon	1
		Madagascar	1
		Malta	36
		Mexico	5
		Mongolia	1
		Montenegro	13
		Morocco	2
		Mozambique	13
		Qatar	1
		Rwanda	15
		Sao Tome	2
		Saudi Arabia	1
		Serbia	10
		Singapore	2
		Slovenia	21
		South Africa	6
		South Korea	22
		Swaziland	1
		Thailand	4
		T.F.Y.R.O.M.	11
		Timor-Leste	1
		Ukraine	30
		U.A.E.	1

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Ukraine and CERN



- ❑ Cooperation Agreement CERN-Minor Academy of Sciences of Ukraine signed mid 2011



1st national Ukrainian Teachers Programme at CERN in November 2011





As for you, the teachers...

You are a vital basis for all we do!

Build up scientific literacy of society

*Inspire some students to undertake further studies in
science & engineering*

*Some may continue into research (Not only in physics
Not necessarily in particle physics)*

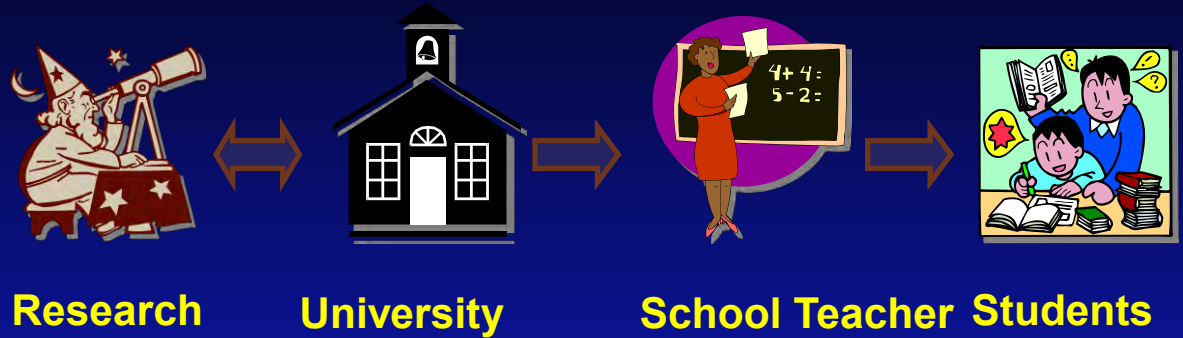
All will contribute to advancing society



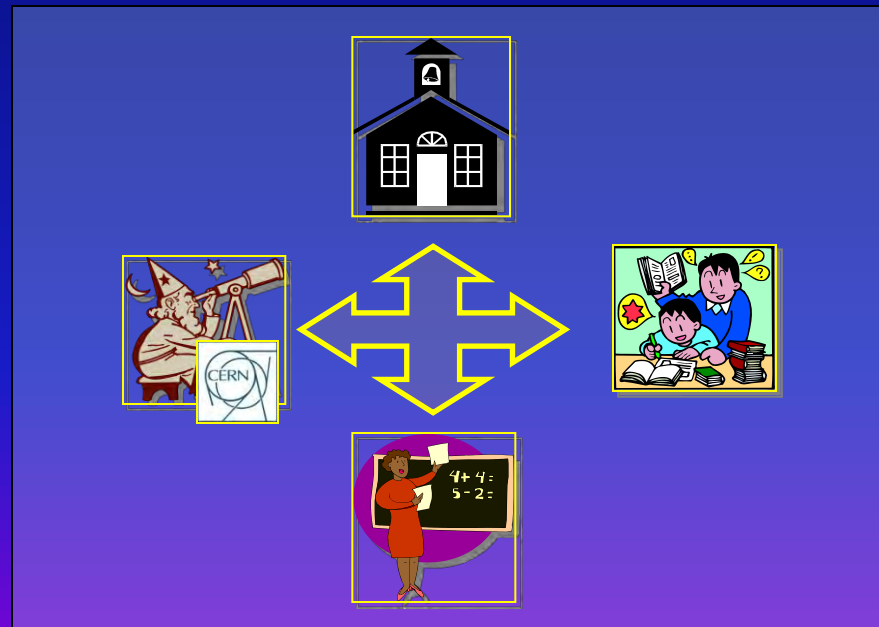
Objective of Teacher Programmes

To bring modern research closer to schools

OLD



NEW





We invite you to CERN!

We would be happy if in 4-5 years one of your students comes to CERN as a Summer Student or Technical Student or....

See you at CERN !

Thank you
ДЯКУЄМ

