CERN – A Gateway to Science and Technology

Prof. Emmanuel Tsesmelis
Deputy Head of International Relations
Directorate-General Unit, CERN

Bratislava, Slovak Republic
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The Mission of CERN

- Push forward the frontiers of knowledge

  E.g. the secrets of the Big Bang ... the matter like within the first moments of th... istence?

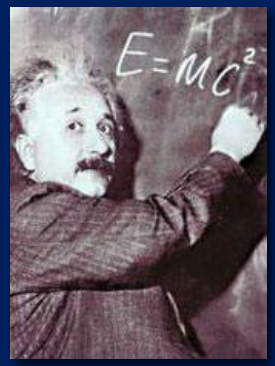
- Develop new tec... accelerators an...

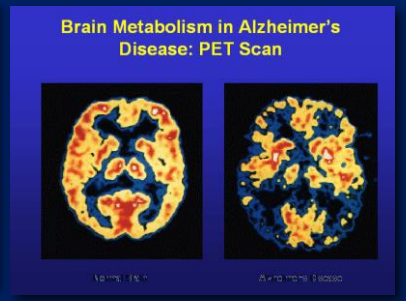
  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy

- Train scientists and engineers of tomorrow

- Unite people from different countries and cultures

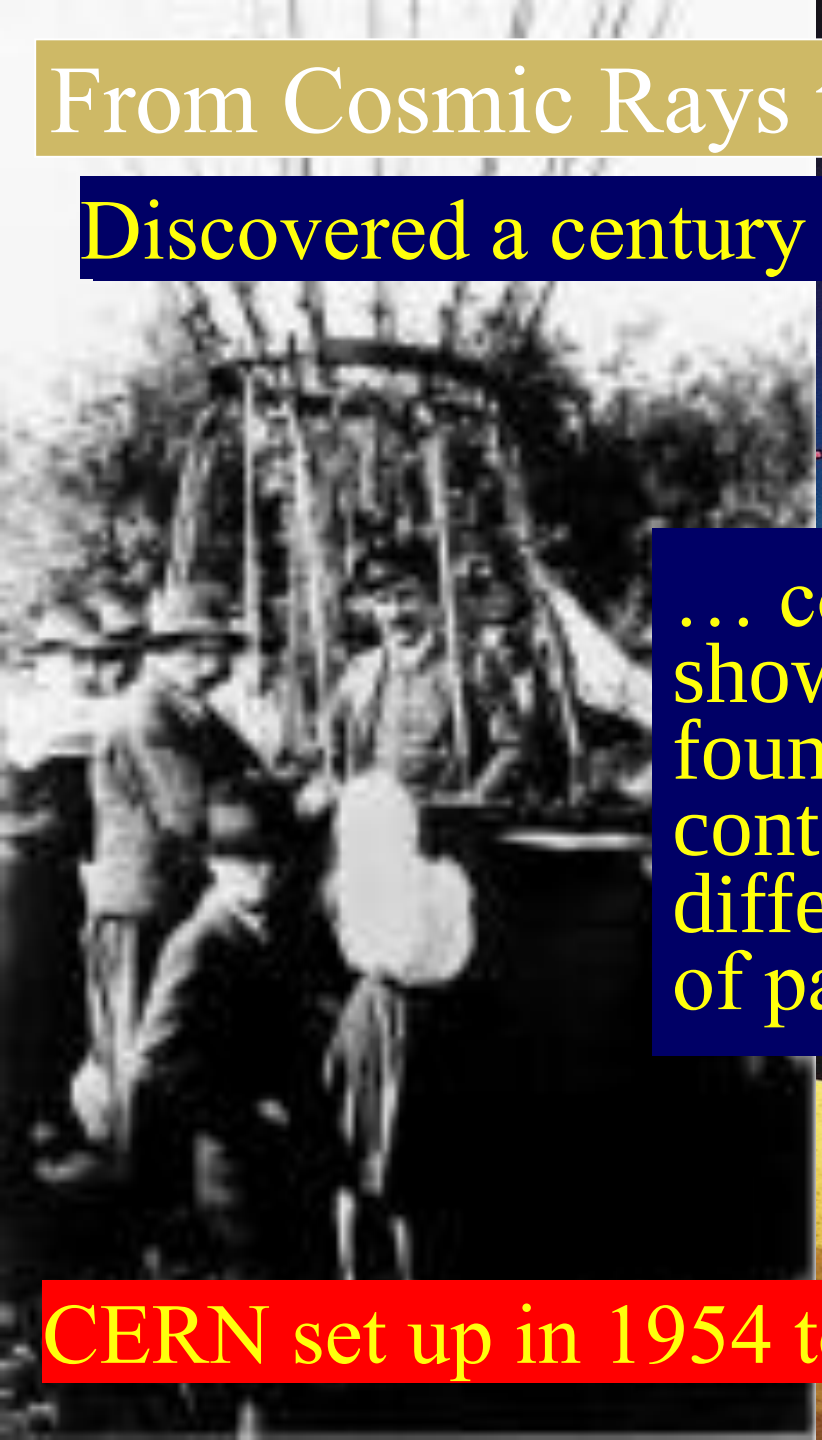


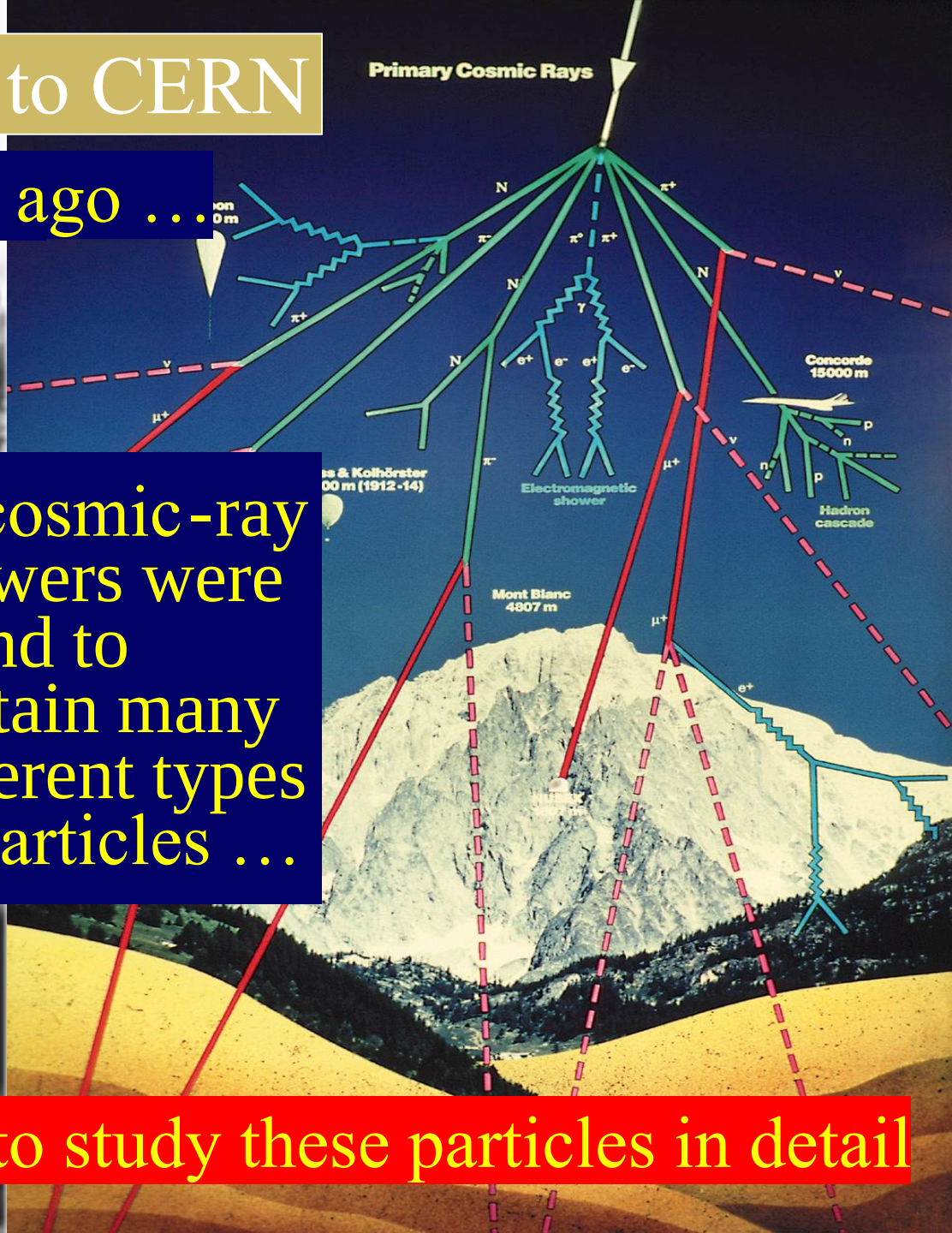


Discovery Science

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 of Particle Physics

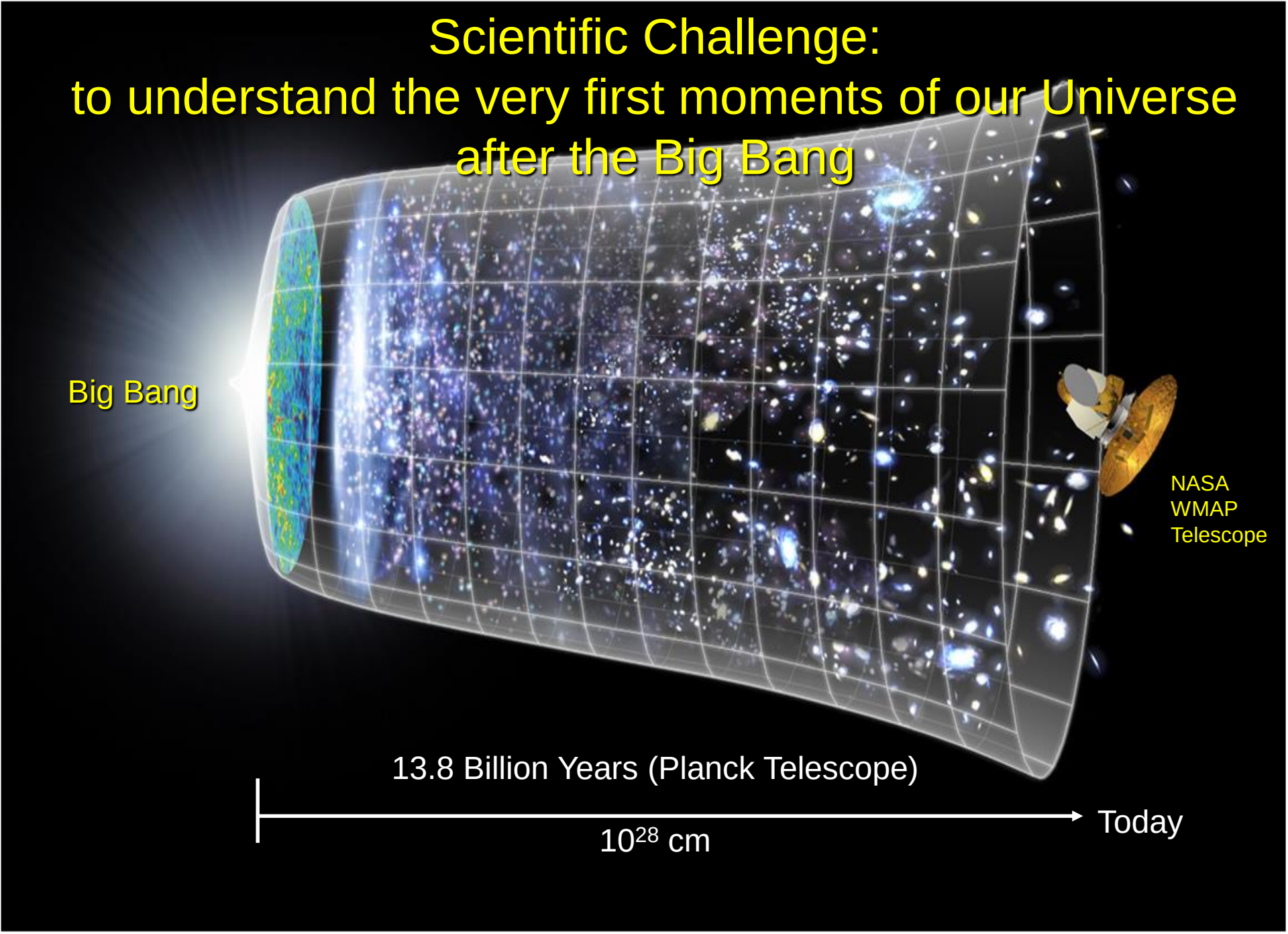
= Cosmic DNA

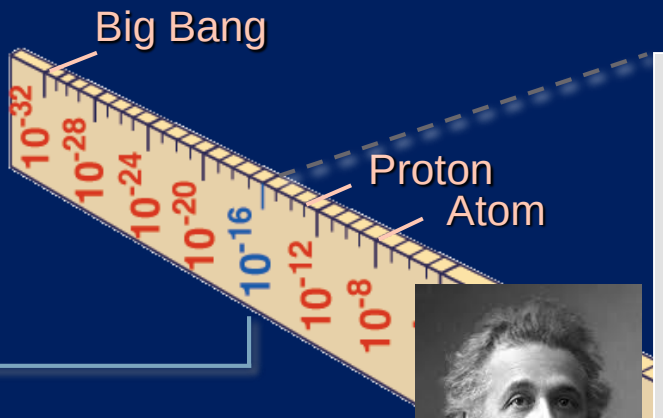
The matter particles

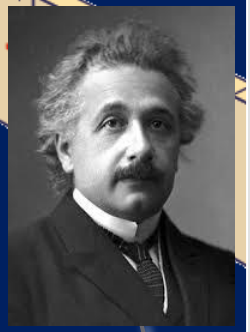
The fundamental interactions

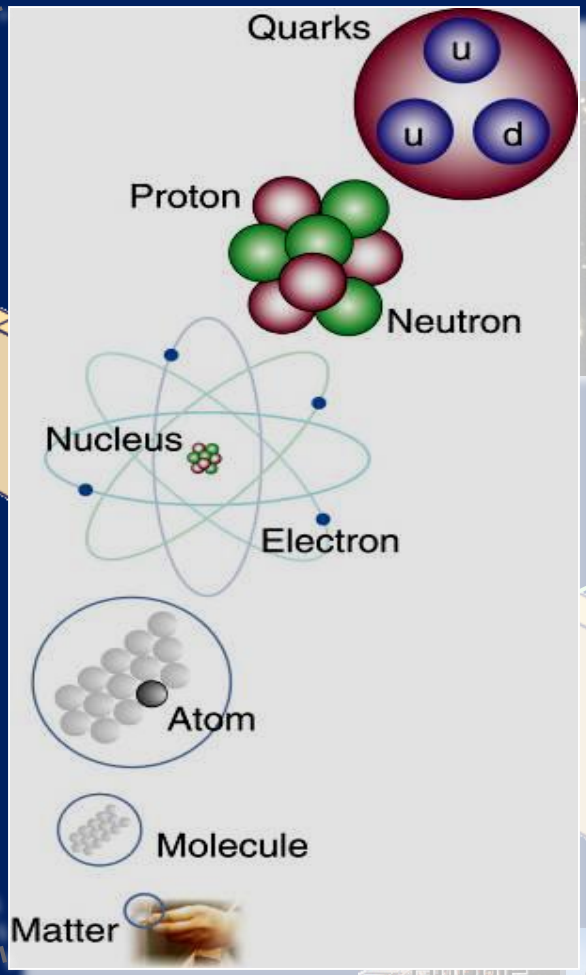
Gravitation electromagnetism weak nuclear force strong nuclear force

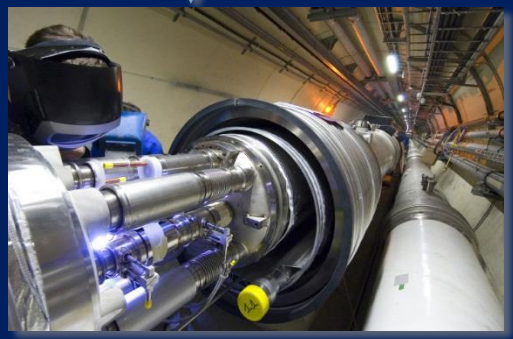
Scientific Challenge:
to understand the very first moments of our Universe after the Big Bang





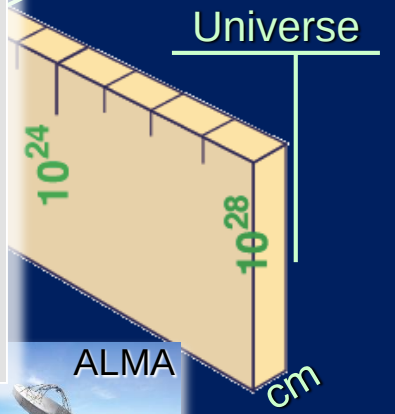


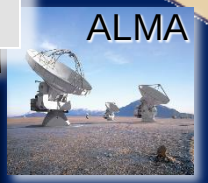




LHC

Super-Microscope



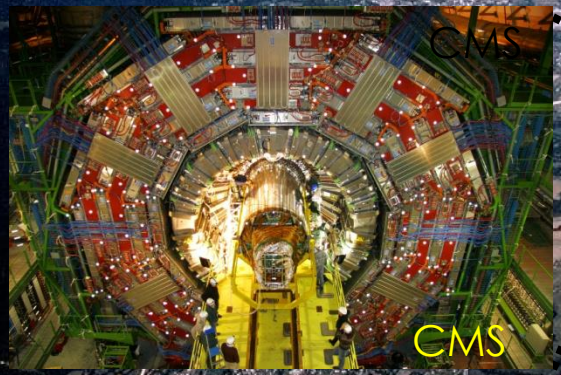


Study physics laws of first moments after Big Bang
increasing Symbiosis between Particle Physics,
Astrophysics and Cosmology

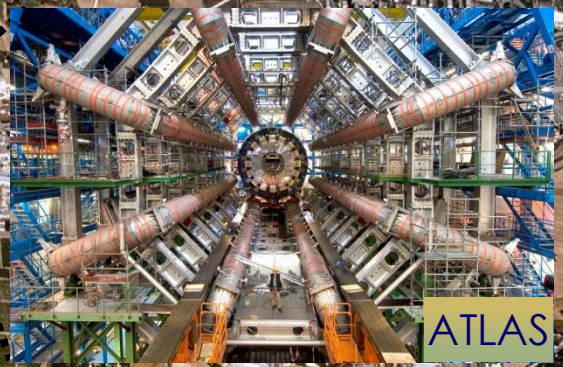
The Large Hadron Collider

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 LHC Arcs

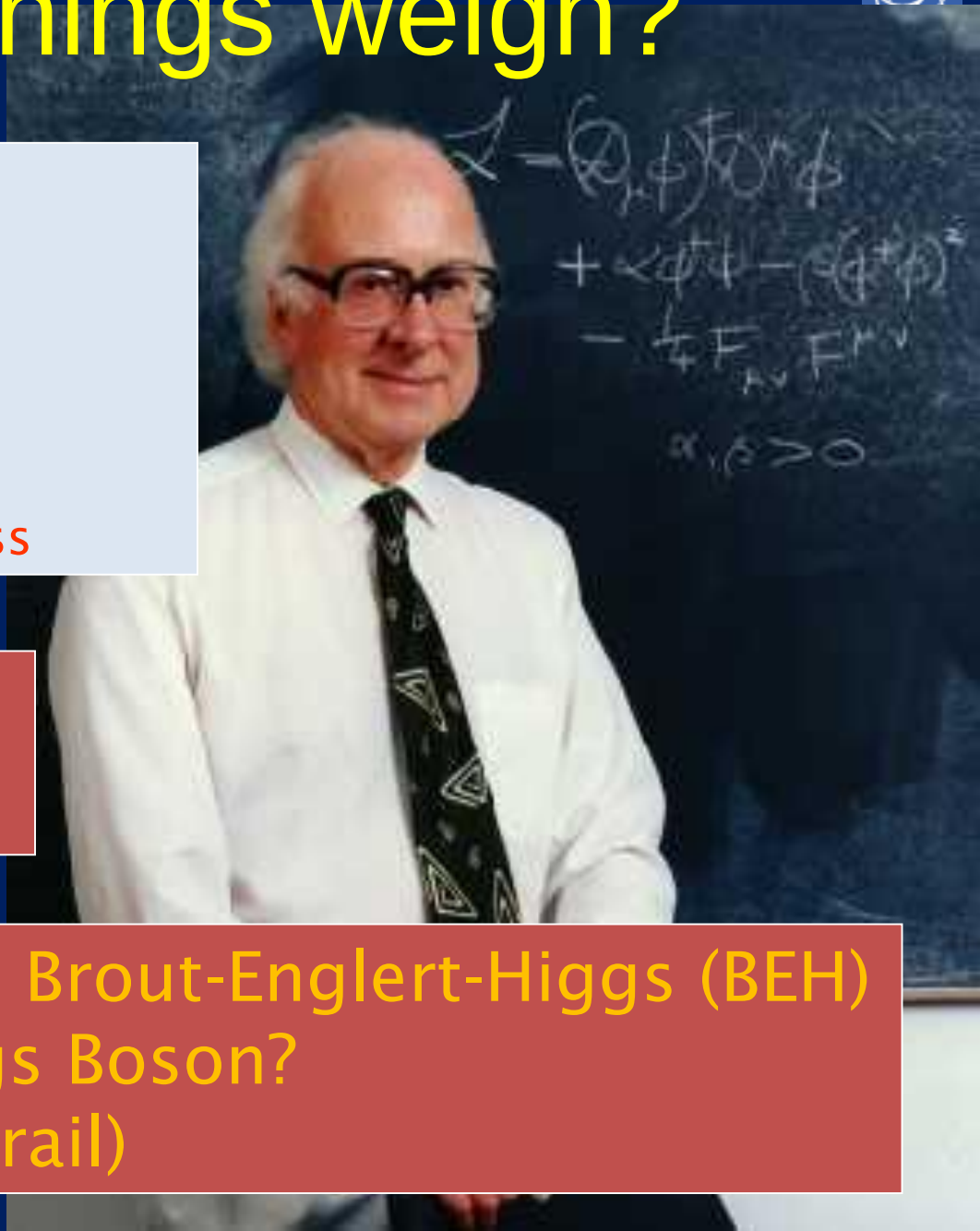
The Discovery of the Higgs Boson

Why do things weigh?

Newton:
Weight proportional to Mass

Einstein:
Energy related to Mass

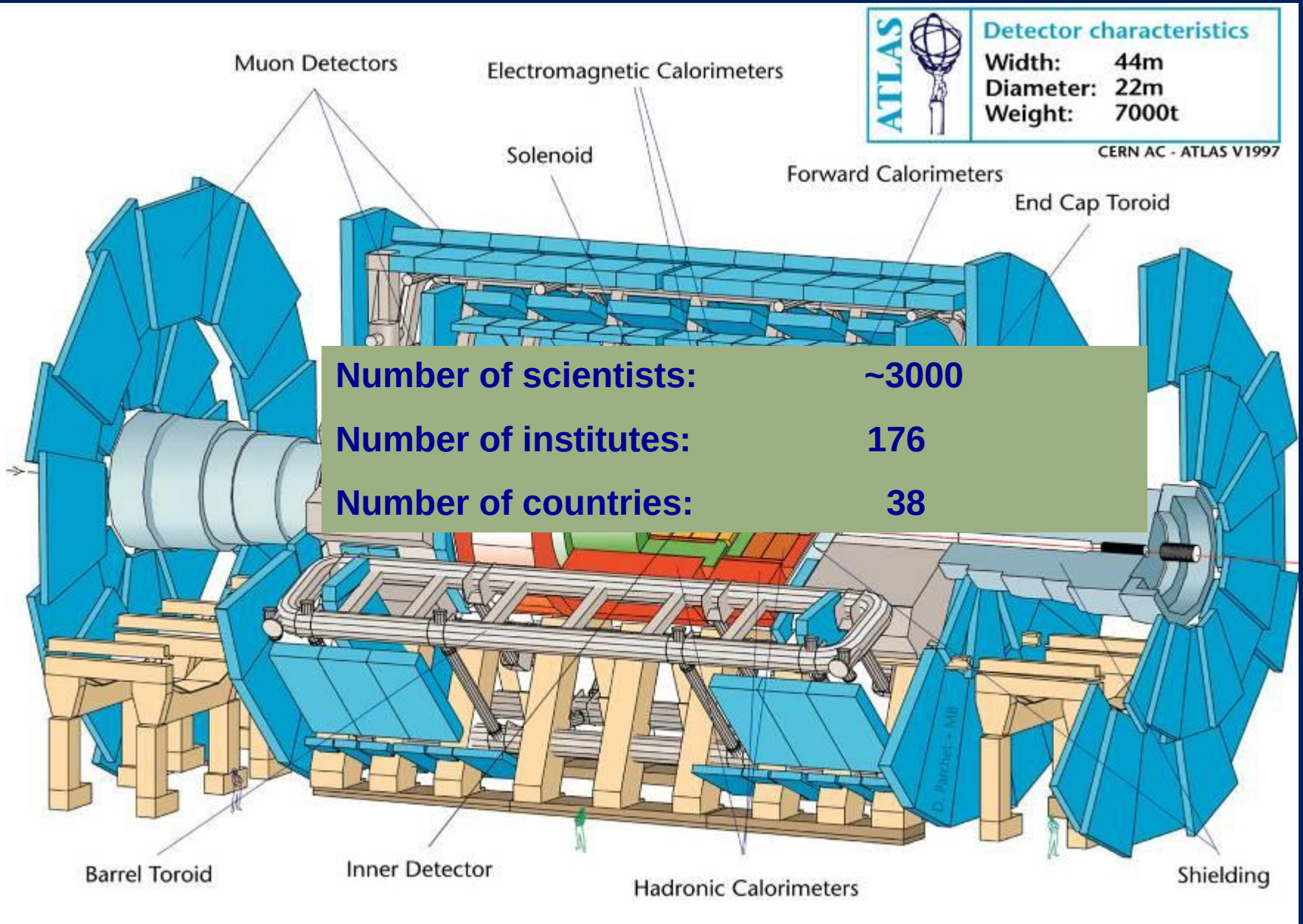
Neither explained origin of Mass



Where do the masses come from?

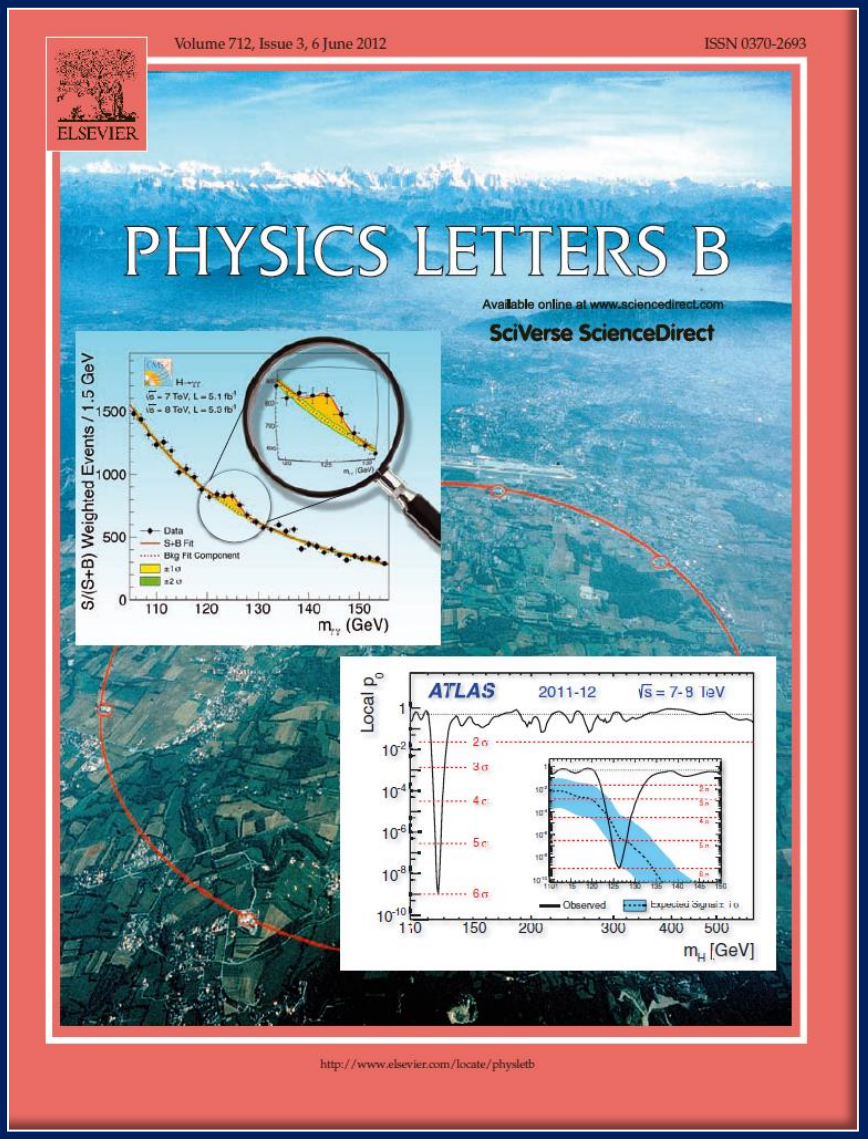
Are masses due to the Brout-Englert-Higgs (BEH) Mechanism & the Higgs Boson?
(the physicists' Holy Grail)

The ATLAS Experiment



The ATLAS Experiment

The Highlight of a Remarkable Year 2012

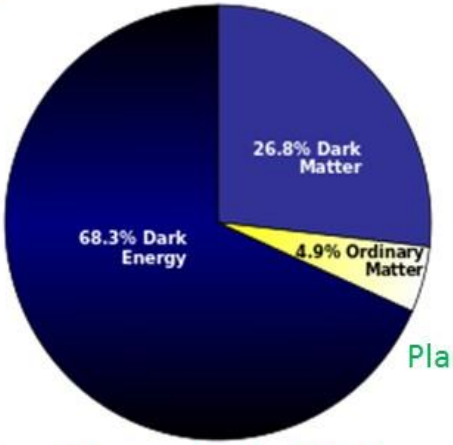


Nobel Prize in Physics 2013

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs "*for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider*".

The Higgs boson discovery is only the beginning!
What's next?

- Is it ***the*** Higgs boson…or one of many?
- Measure with precision the properties of the discovered Higgs boson
  - …its properties could give information on Dark Matter
  - …its properties could give first indications on Dark Energy



Planck Space Observatory, ESA (2013)

Our understanding of the Universe is changing!

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

The Predictable Future - *LHC Timeline*

2009 — Start of LHC

Run 1: 7 and 8 TeV centre-of-mass energy, luminosity ramping up to several 10^{33} cm^{-2} s^{-1}, ~25 fb^{-1} delivered

2013/14 — LS1: LHC shut-down to prepare machine for design energy and nominal luminosity

Run 2: Ramp up luminosity to … and centre-of-mass ener… …30 to 100 fb^{-1})

2018 — LS2 - Injector a… …ultimate luminosity

Ru… …to 2.2 x nominal, reaching ~100 fb^{-1} / year acc… …ed fb^{-1}

~2023 — LS3: High… …inosity LHC. New focusing magnets and CRAB cavities for very high luminosity with levelling

Run 4: Collect data until >3000 fb^{-1}

>2035

Study of the properties of the Higgs Boson
and
Physics beyond the Standard Model

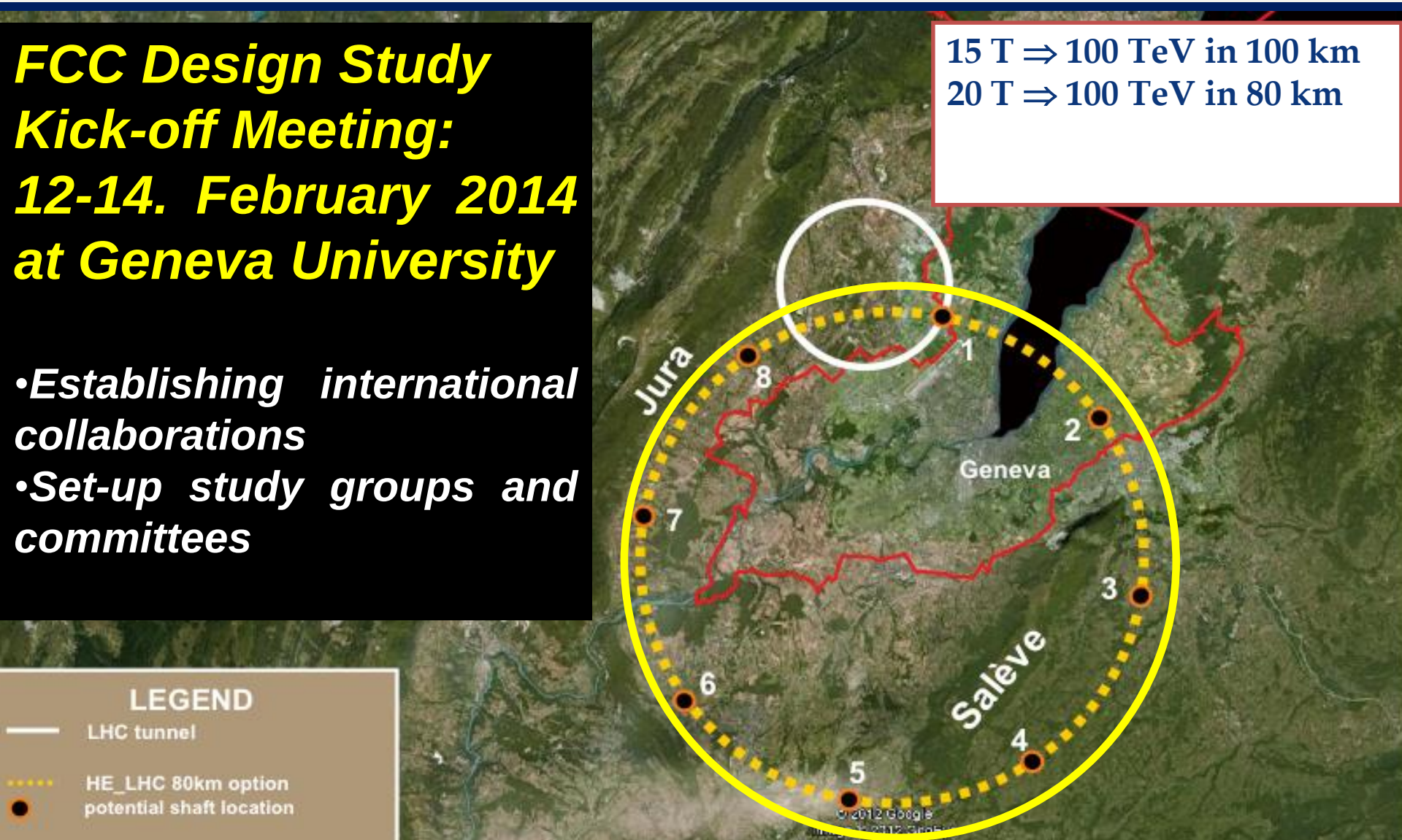
80-100 km tunnel infrastructure in Geneva area – design driven by pp-collider requirements

with possibility of e+-e- (TLEP) and p-e (VLHeC)

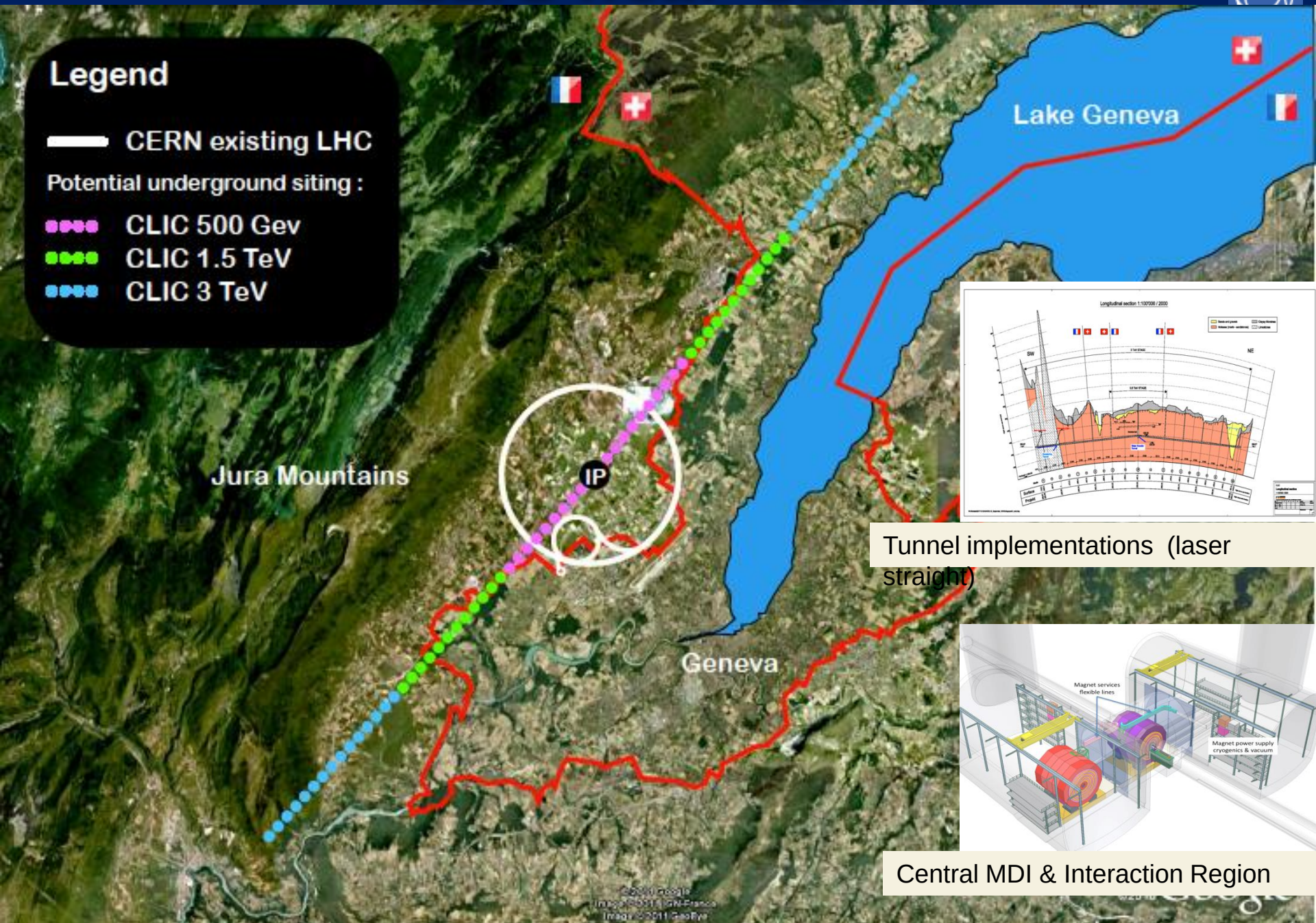
FCC Design Study Kick-off Meeting: 12-14. February 2014 at Geneva University

- ***Establishing international collaborations***
- ***Set-up study groups and committees***

15 T ⇒ 100 TeV in 100 km
20 T ⇒ 100 TeV in 80 km



CLIC near CERN



Tunnel implementations (laser straight)

Central MDI & Interaction Region

Knowledge and Technology Transfer

Innovation Education CERN uniting people Research

CERN Technologies and Innovation
Example – Medical Applications

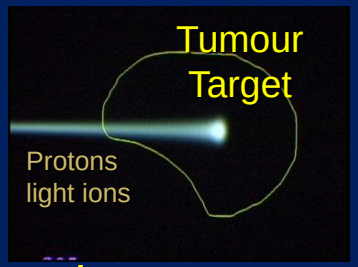
Combining Physics, ICT, Biology and Medicine to fight cancer

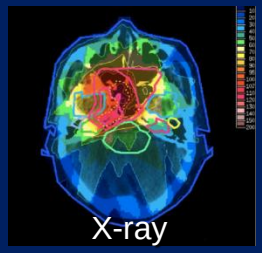
Accelerating particle beams

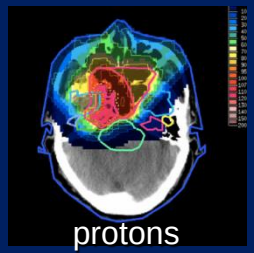
~30’000 accelerators worldwide

~17’000 used for medicine

Hadron Therapy



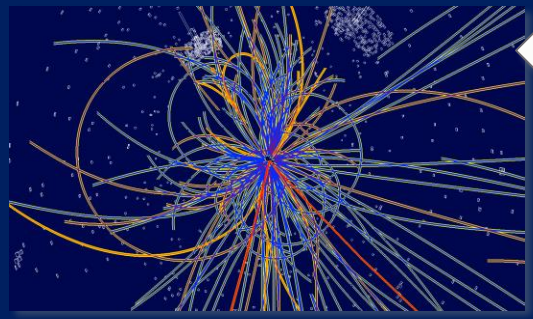




Leadership in Ion Beam Therapy now in Europe and Japan

>70’000 patients treated worldwide (30 facilities)

>21’000 patients treated in Europe (9 facilities)

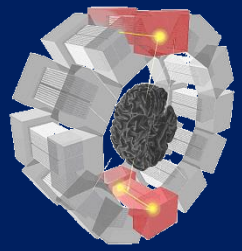


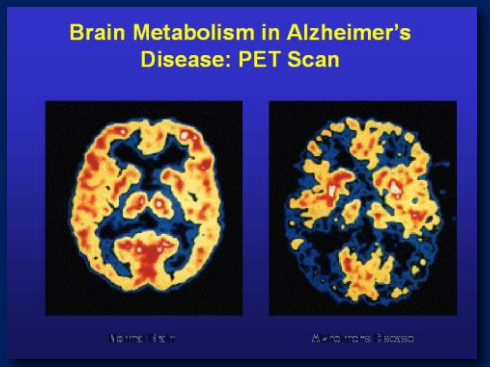
Detecting particles

Imaging

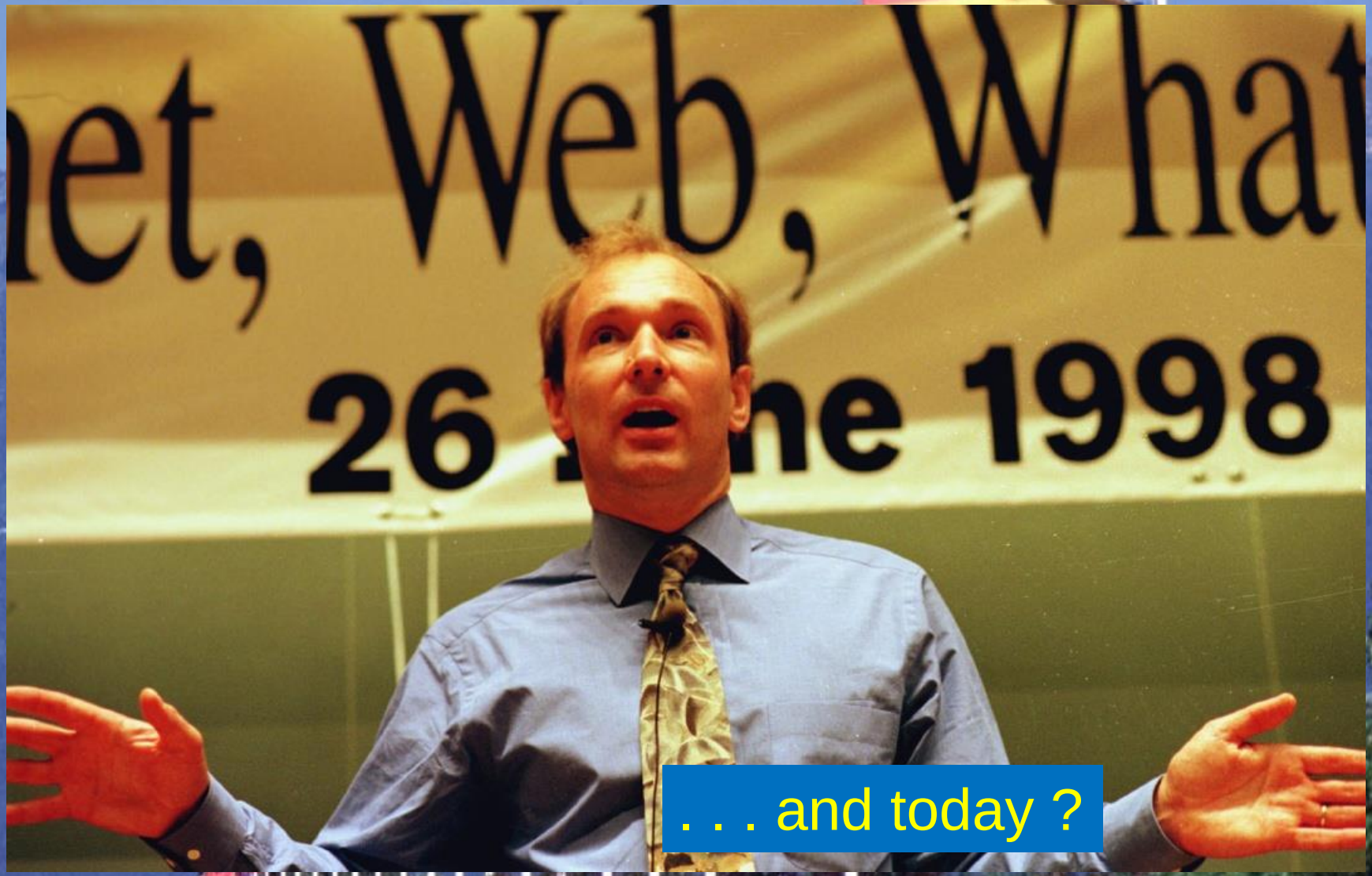
Clinical trial in Portugal for new breast imaging system (ClearPEM)

PET Scanner





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



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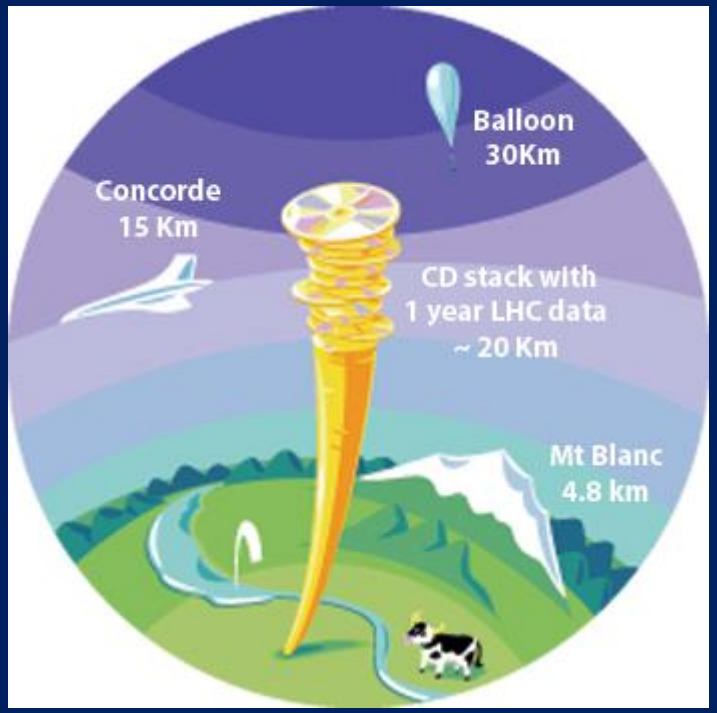
The LHC Data Challenge

- Experiments were anticipated to produce about **25 Million Gigabytes** of data each year (~30 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.



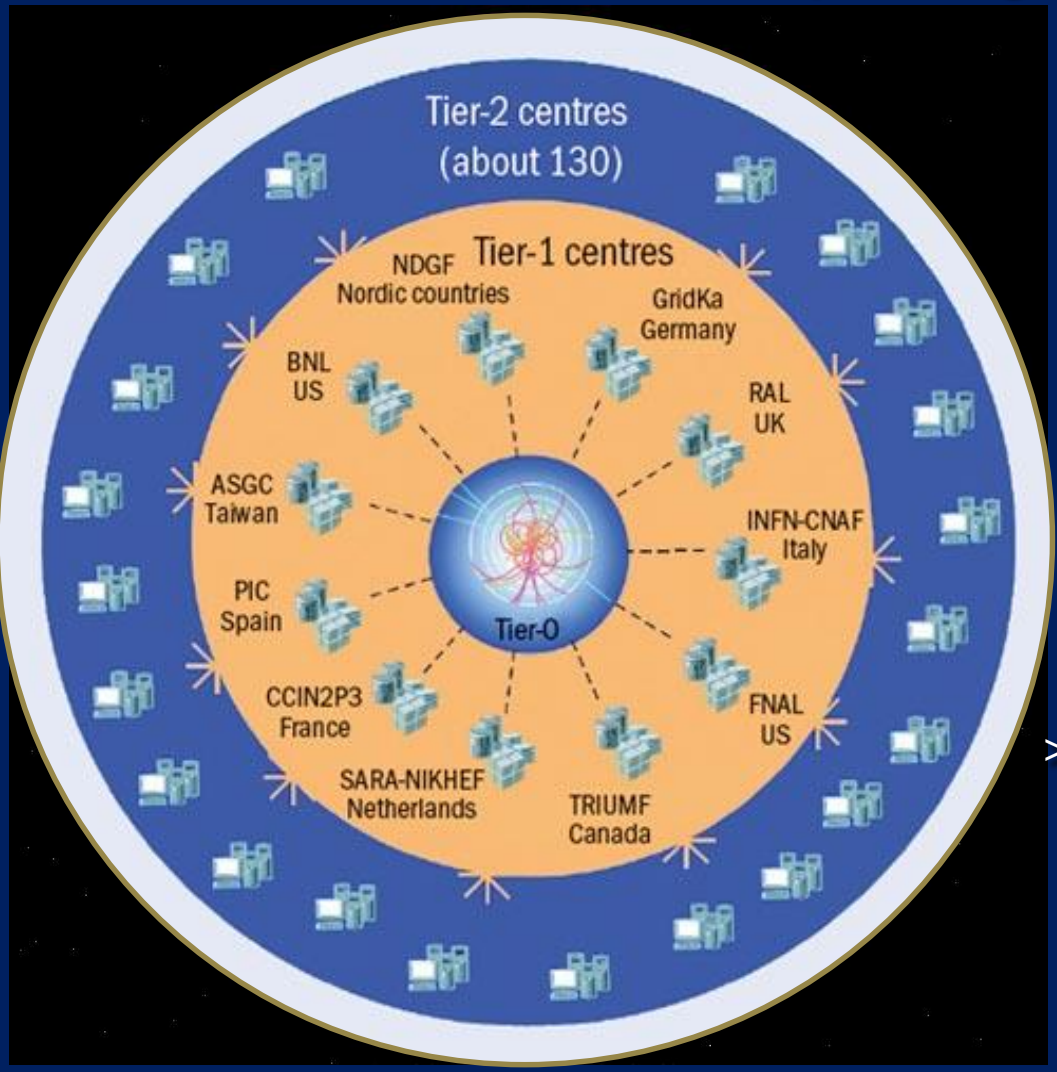
GRID Computing

The Worldwide LHC Computing Grid

Tier-0 (CERN and Hungary): data recording, reconstruction and distribution

Tier-1: permanent storage, re-processing, analysis

Tier-2: Simulation, end-user analysis



nearly 160 sites, 35 countries

~250'000 cores

173 PB of storage

> 2 million jobs/day

10 Gb links

WLCG:
An International collaboration to distribute and analyse LHC data

Integrates computer centres worldwide that provide computing and storage resource into a single infrastructure accessible by all LHC physicists

CERN Education Activities

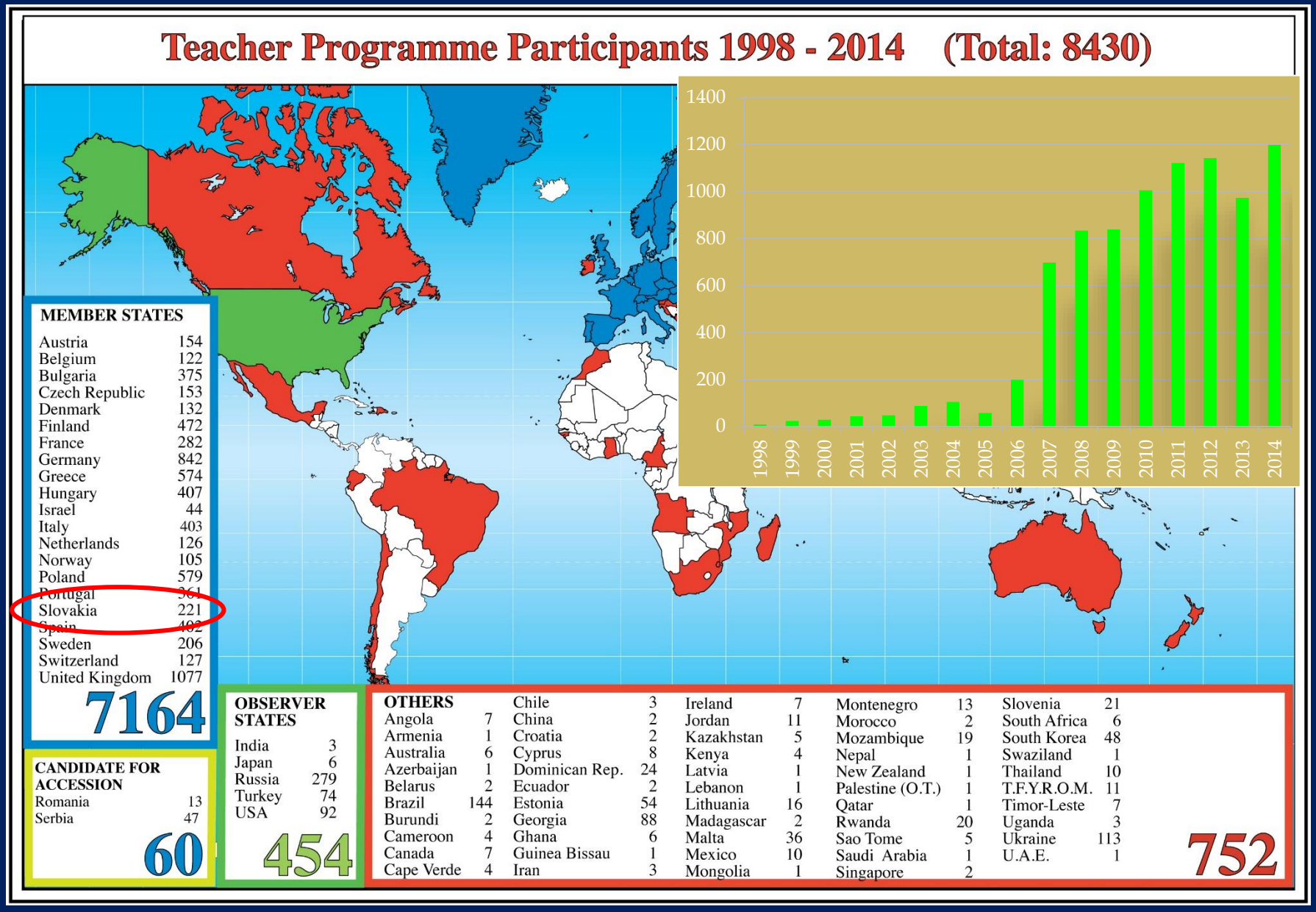
Scientists at CERN
Academic Training Programme

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 Teacher Programme



Summer Students 2014

Summer Students 2014

MEMBER STATES 149

Austria	3
Belgium	4
Bulgaria	2
Czech Republic	6
Denmark	6
Finland	2
France	15
Germany	21
Greece	9
Hungary	2
Israel	3
Italy	11
Netherlands	10
Norway	5
Poland	5
Portugal	4
Slovakia	3
Spain	11
Sweden	6
Switzerland	4
United Kingdom	17

OBSERVERS 45

India	10
Japan	5
Russia	10
Turkey	7
USA	13

CANDIDATE FOR ACCESSION

Romania	2

ASSOCIATE MEMBER IN THE PRE-STAGE TO MEMBERSHIP

Serbia	2

OTHERS

Albania	1	Cameroun	1	Estonia	5	Lithuania	4	Senegal	1	U.A.E.	2
Algeria	3	Canada	3	Georgia	1	Malaysia	4	Singapore	1	Venezuela	1
Argentina	1	China	8	Ghana	1	Malta	3	Slovenia	1		
Australia	1	Colombia	1	Indonesia	2	Mexico	1	South Africa	2		
Bangladesh	1	Costa Rica	2	Iran	3	Nepal	1	Swaziland	1		
Belarus	1	Croatia	1	Ireland	1	Pakistan	3	Syria	1		
Bolivia	1	Cyprus	2	Korea, South	1	Palestine	1	Thailand	4		
Bosnia	1	Ecuador	3	Latvia	1	Philippines	1	T.F.Y.R.O.M.	2		
Brazil	1	Egypt	5	Lebanon	2	Puerto Rico	1	Ukraine	4		

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CERN – The European Organization for Nuclear Research

CERN: founded in 1954: 12 European States
"Science for Peace"
Today: 21 Member States

~ 2300 staff
~ 1300 other paid personnel
~ 11500 scientific users

Budget (2015) ~1000 MCHF

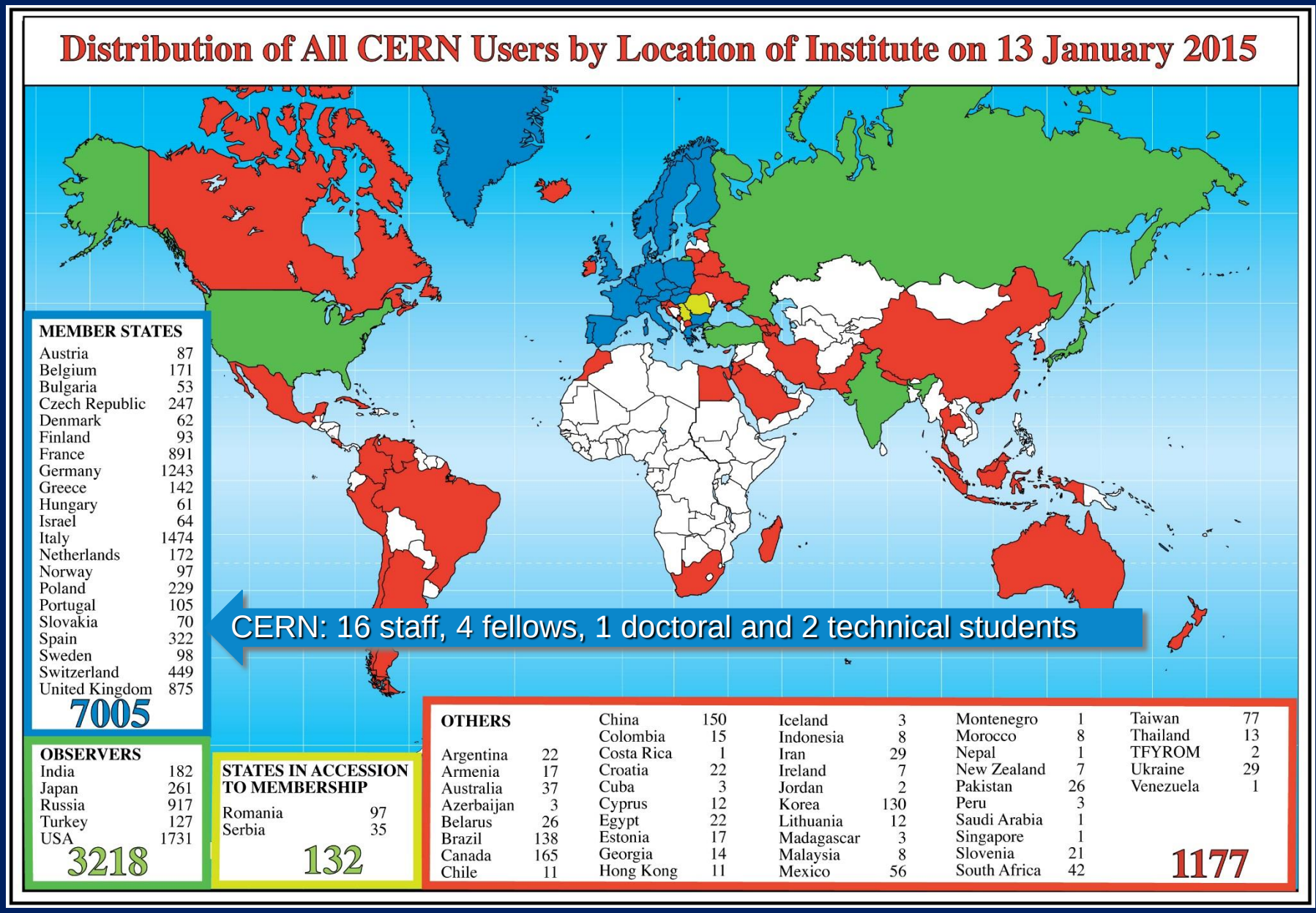
Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom

States in accession to Membership: Romania, Serbia

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

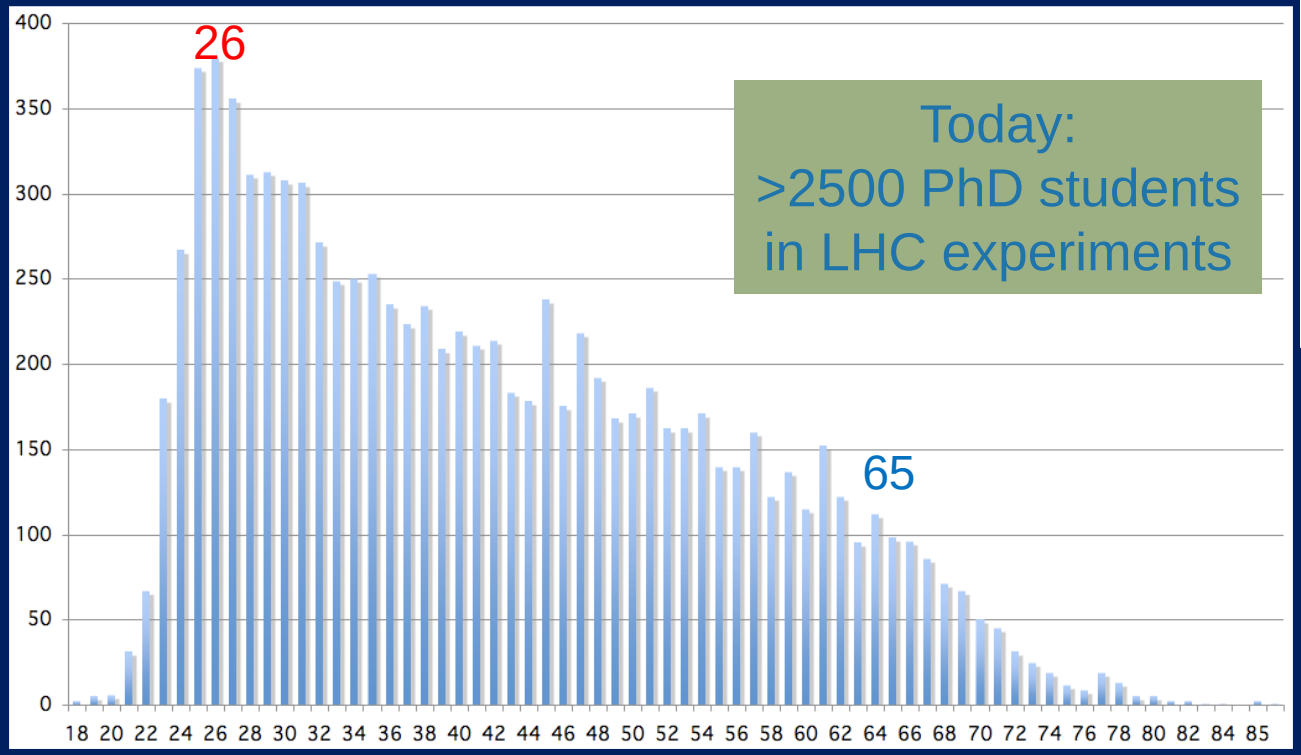
Observers to Council: India, Japan, Russia, Turkey, United States of America; European Union, JINR and UNESCO

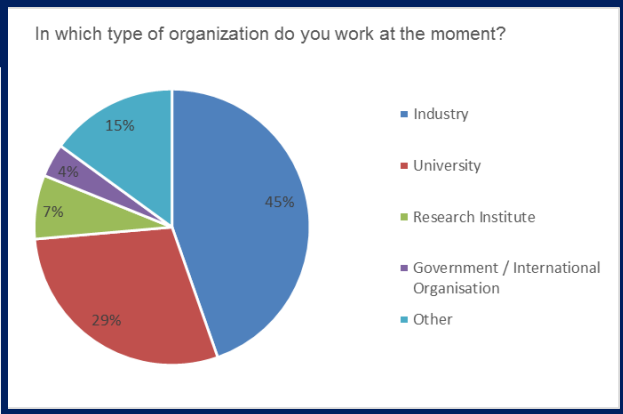
Science is getting more and more global

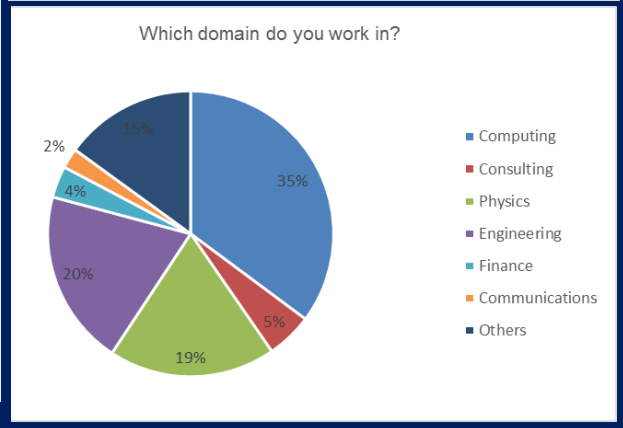


Age Distribution of Scientists

- and where they go afterwards







They do not all stay: where do they go?

Slovakia and CERN

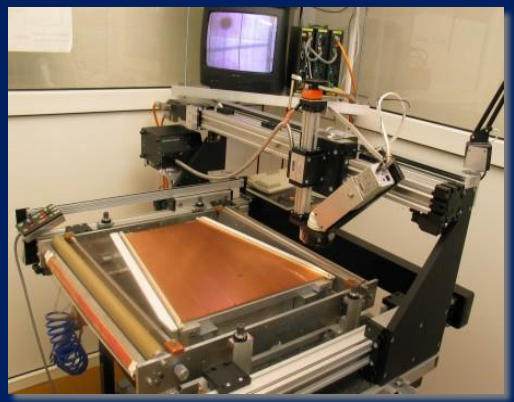
- Slovakia became CERN Member State in 1993
- Today research in particle physics is carried out mainly at 4 Institutes:
  - Comenius University Bratislava
  - Institute of Experimental Physics of the Slovak Academy of Sciences, Košice
  - Institute of Physics of the Slovak Academy of Science, Bratislava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

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

Also participation in several fixed-target experiments – NA62, ISOLDE

Slovakia and CERN

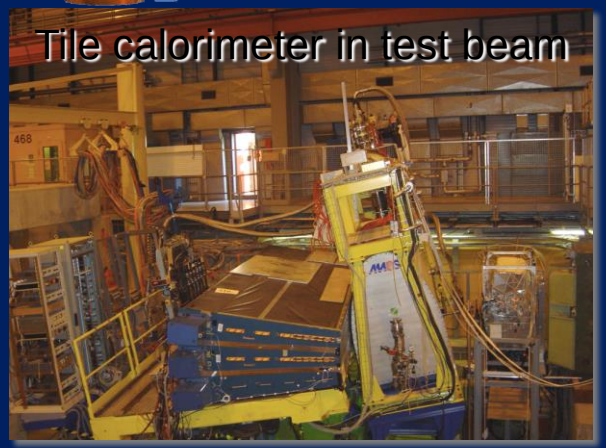
Contributions to ALICE
16 members



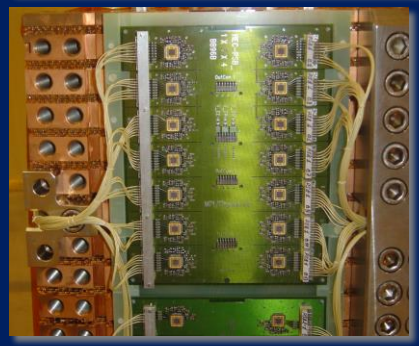
TPC: Bratislava
Production and test of 26 readout chambers at Bratislava Detector Laboratory

Pixel detector:
Košice
Electronics for readout

Contributions to ATLAS
15 members



Tile calorimeter:
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) in Tlmače

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

CERN – innovate, discover, publish, share

… and bring the world together


LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km
Thank You!
Ďakujem !
CERN
Accelerating Science and Innovation