Accelerating Science and Innovation

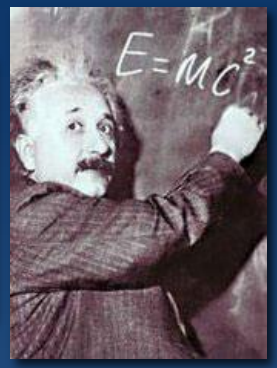
1. Introduction
2. Science, present
3. A Forward Look – Beyond LHC
4. Collaboration with CERN
5. Beyond sciences


CERN
Accelerating Science and Innovation
Introduction - About CERN

The Mission of CERN

- **Push back** the frontiers of knowledge

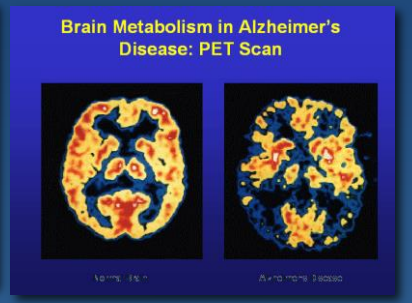
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



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

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy



- **Train** scientists and engineers of tomorrow

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

A word about History …..

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CONVENTION

FOR THE ESTABLISHMENT OF A EUROPEAN ORGANIZATION
FOR NUCLEAR RESEARCH

PARIS, 1st JULY, 1953

As amended

- Signed 1953. Entered into force 29/9/1954.
- By then 12 member states

- Mid 1950's the first accelerator (the SynchroCyclotron) arrived.
- 1957 in operation
- Followed by PS (1960) which is still operational!

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

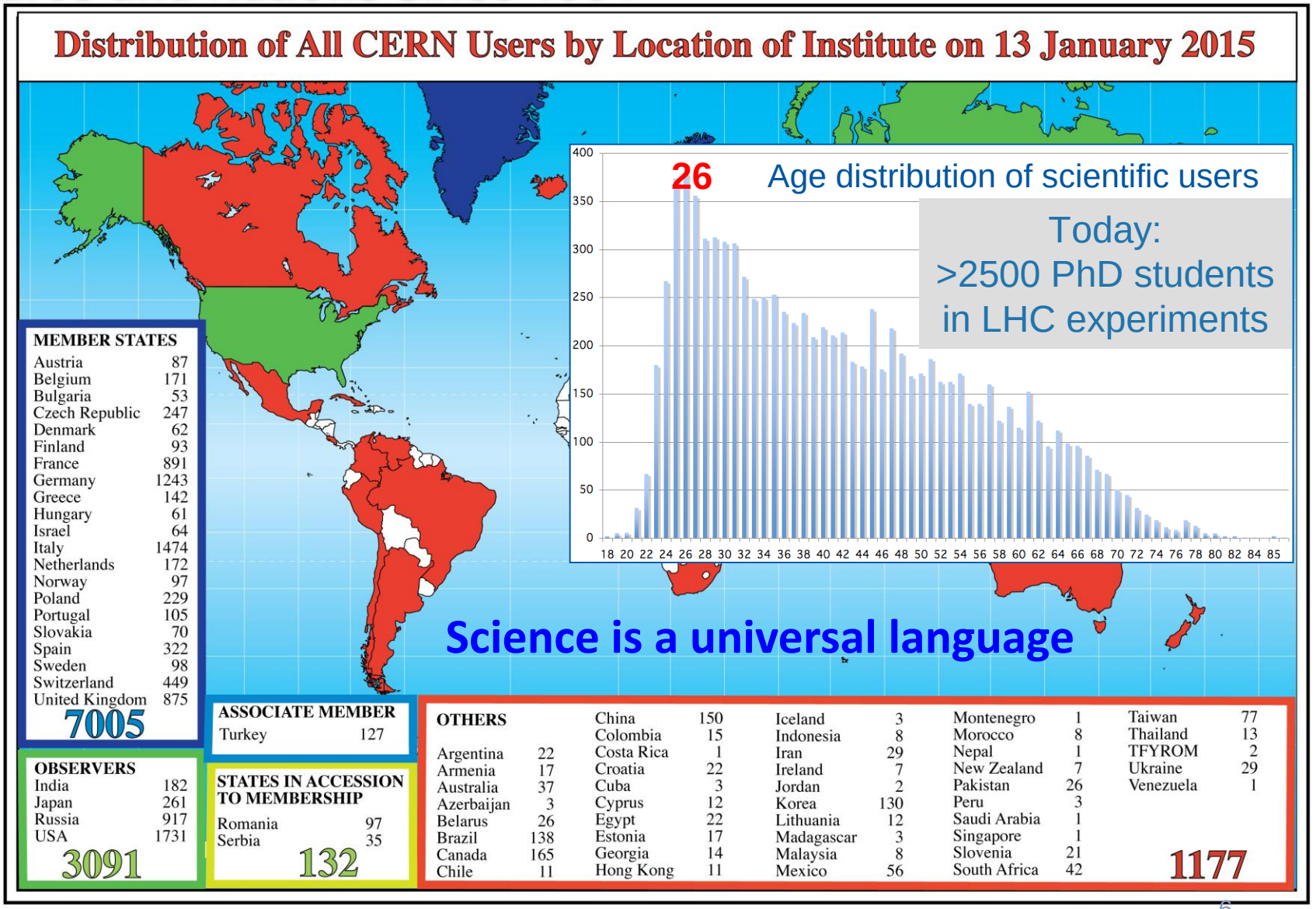
States in accession to Membership: Romania, Serbia

Associate Member State: Turkey

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

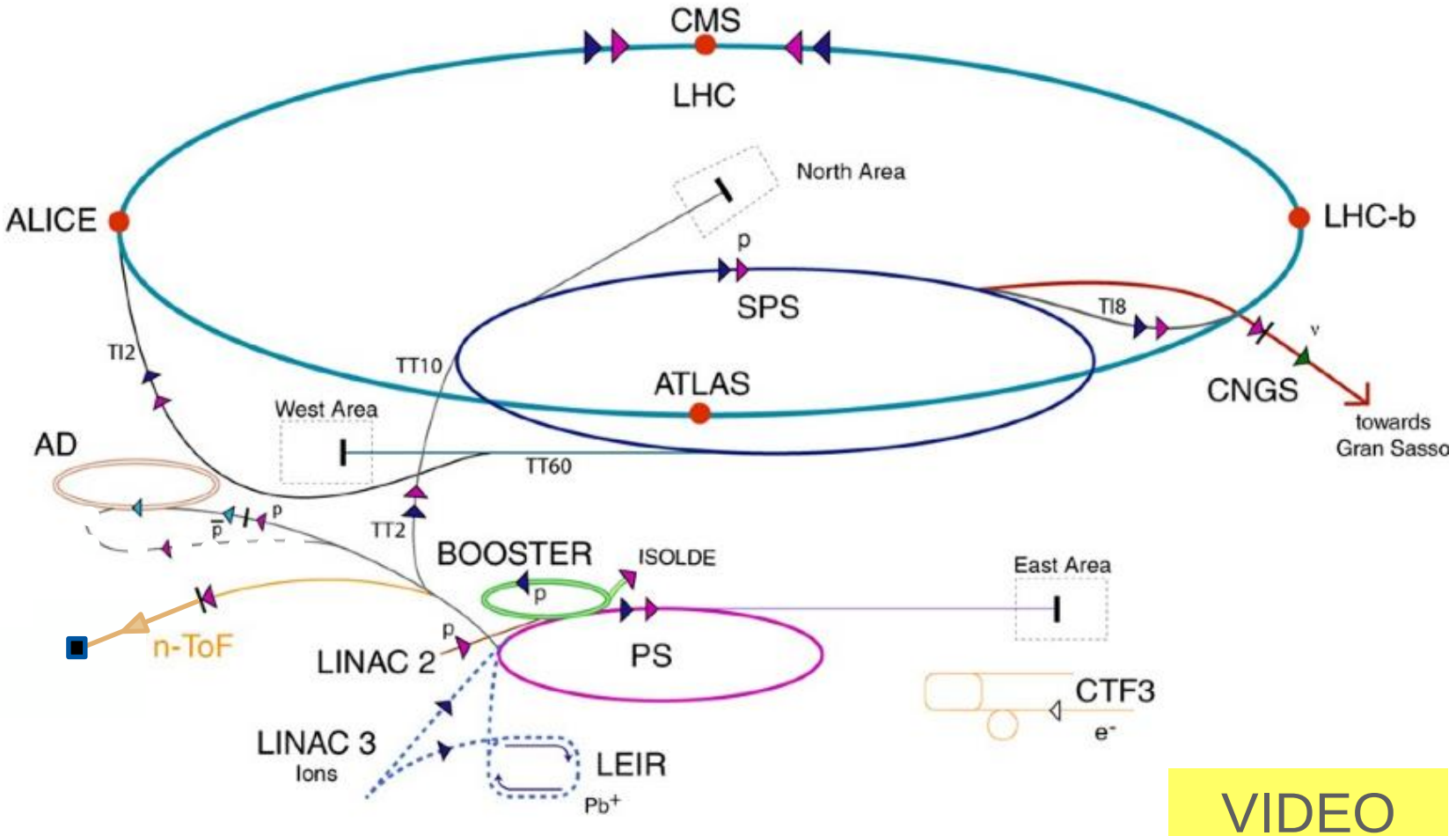
Observers to Council: India, Japan, Russia, United States of America; European Union, JINR and UNESCO

Breaking the Walls between Cultures and Nations since 1954




CERN
Accelerating Science and Innovation
Science, the present
(In)complete overview

CERN Accelerator Complex today



VIDEO

The Particle Physics Landscape at CERN

High Energy Frontier

LHC

Long list of experiments:
AEGIS, ALPHA, ASACUSA, ATRAP, BASE, CAST, CNGS-OPERA, *COMPASS, DIRAC, ISOLDE, NA61to63, nTOF.*

AMS - International space station

CLOUD, ACE.

Non-LHC Particle Physics = o(1000) physicists / o(20) experiments

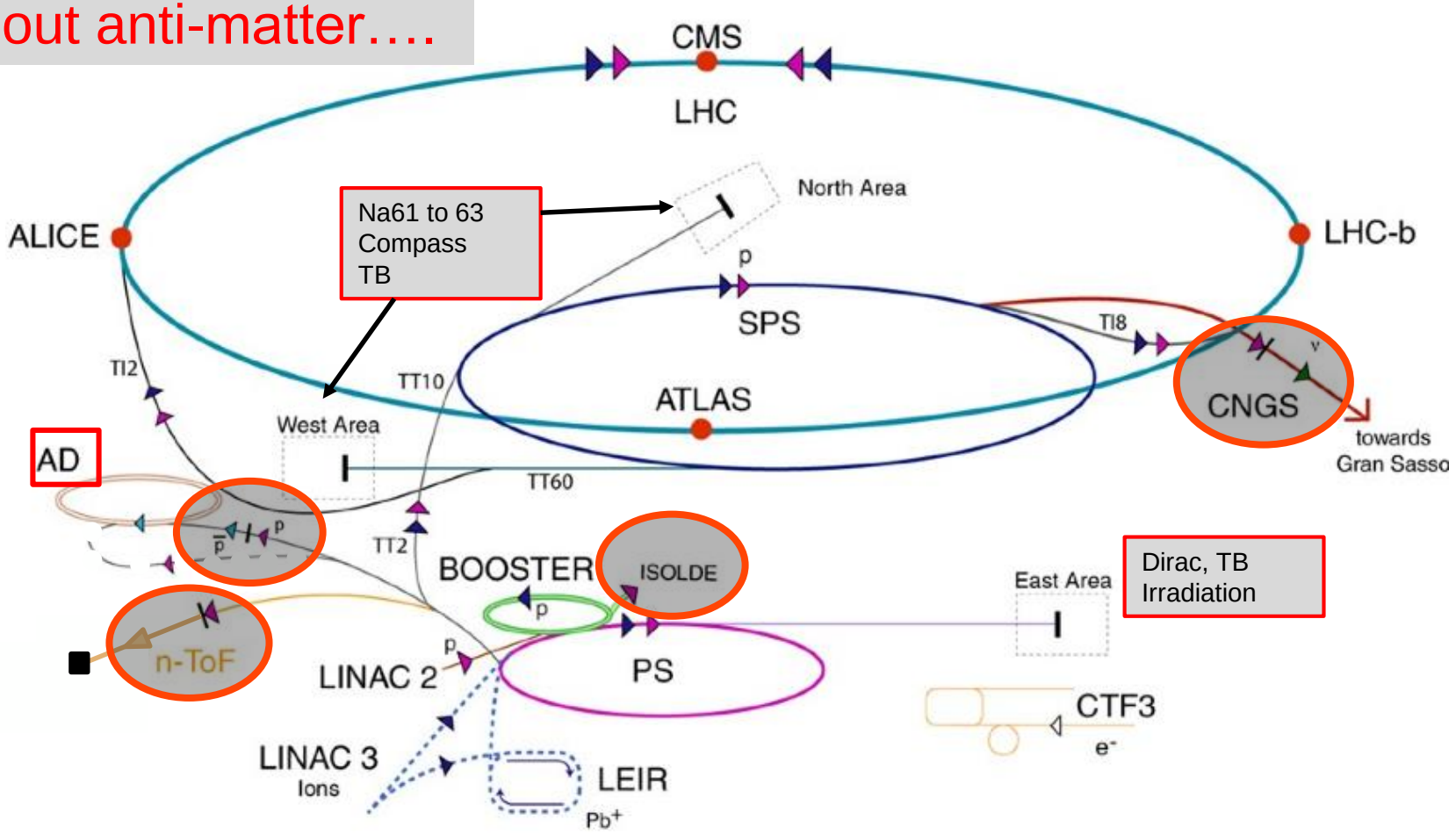
Scientific Diversity at ***unique facilities***

CERN maintains and upgrades these facilities

Complemented and supported by Theory

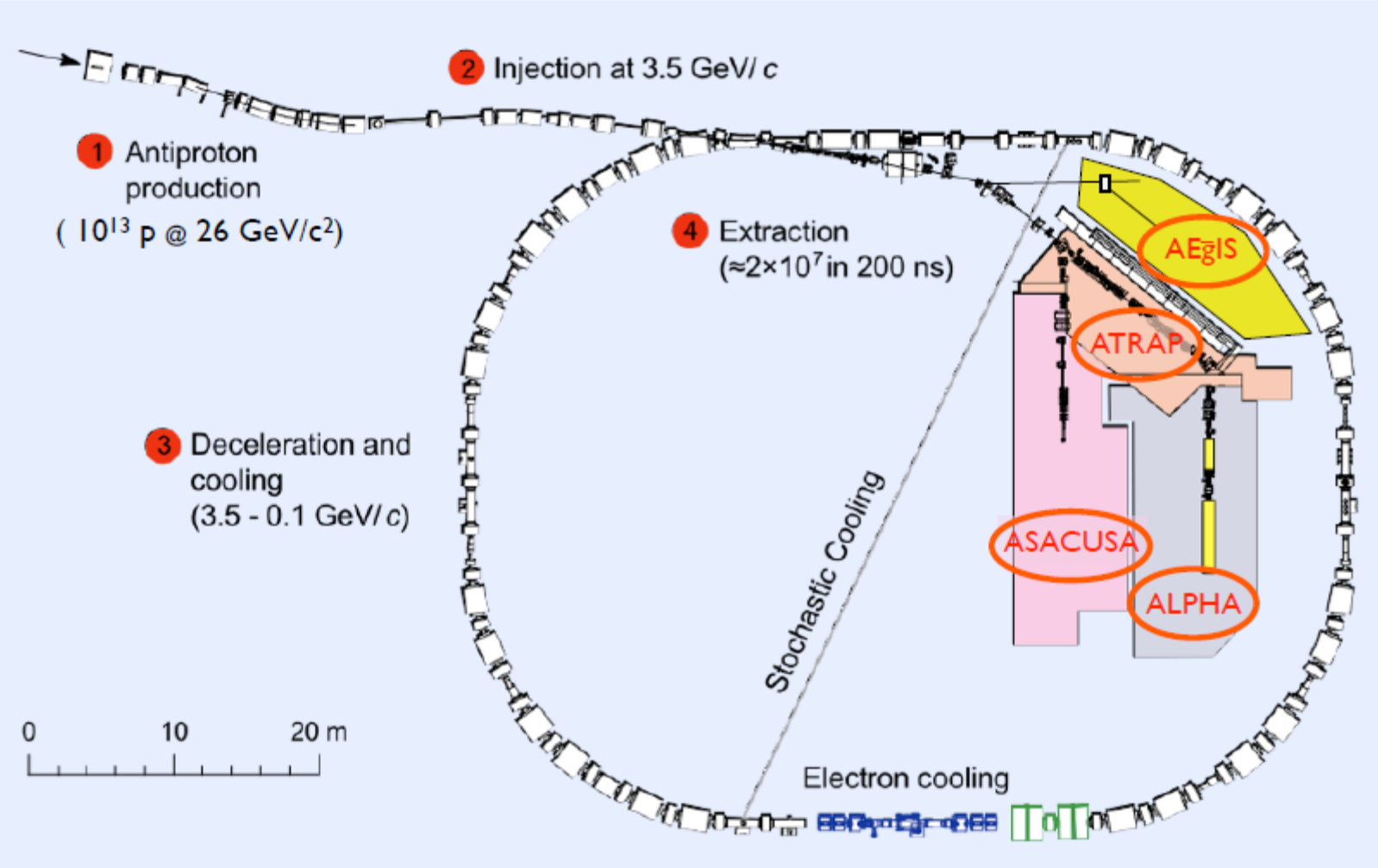
CERN Accelerator Complex

About anti-matter….



AD (current situation)

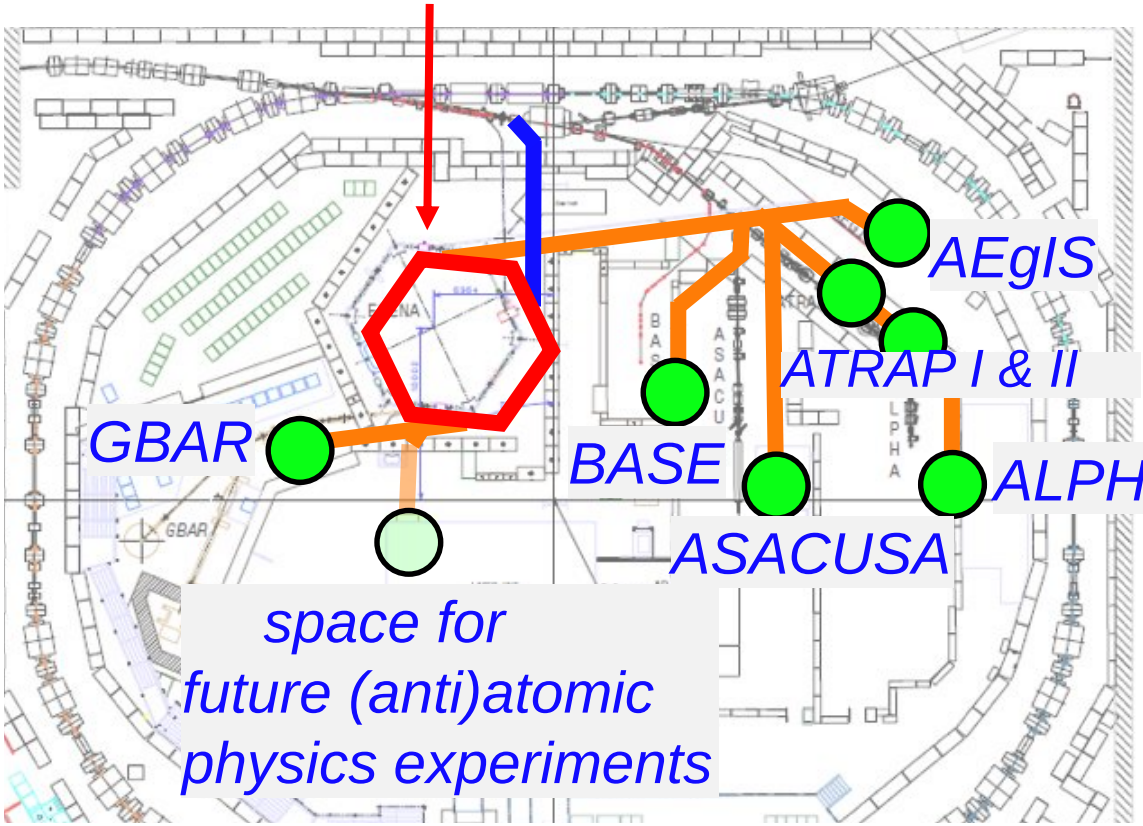
Antiproton decelerator



Study the properties of Antimatter (pbar and Hbar)

- Increasing & continuous demand for antiprotons,
- Current methods for trapping them are very inefficient

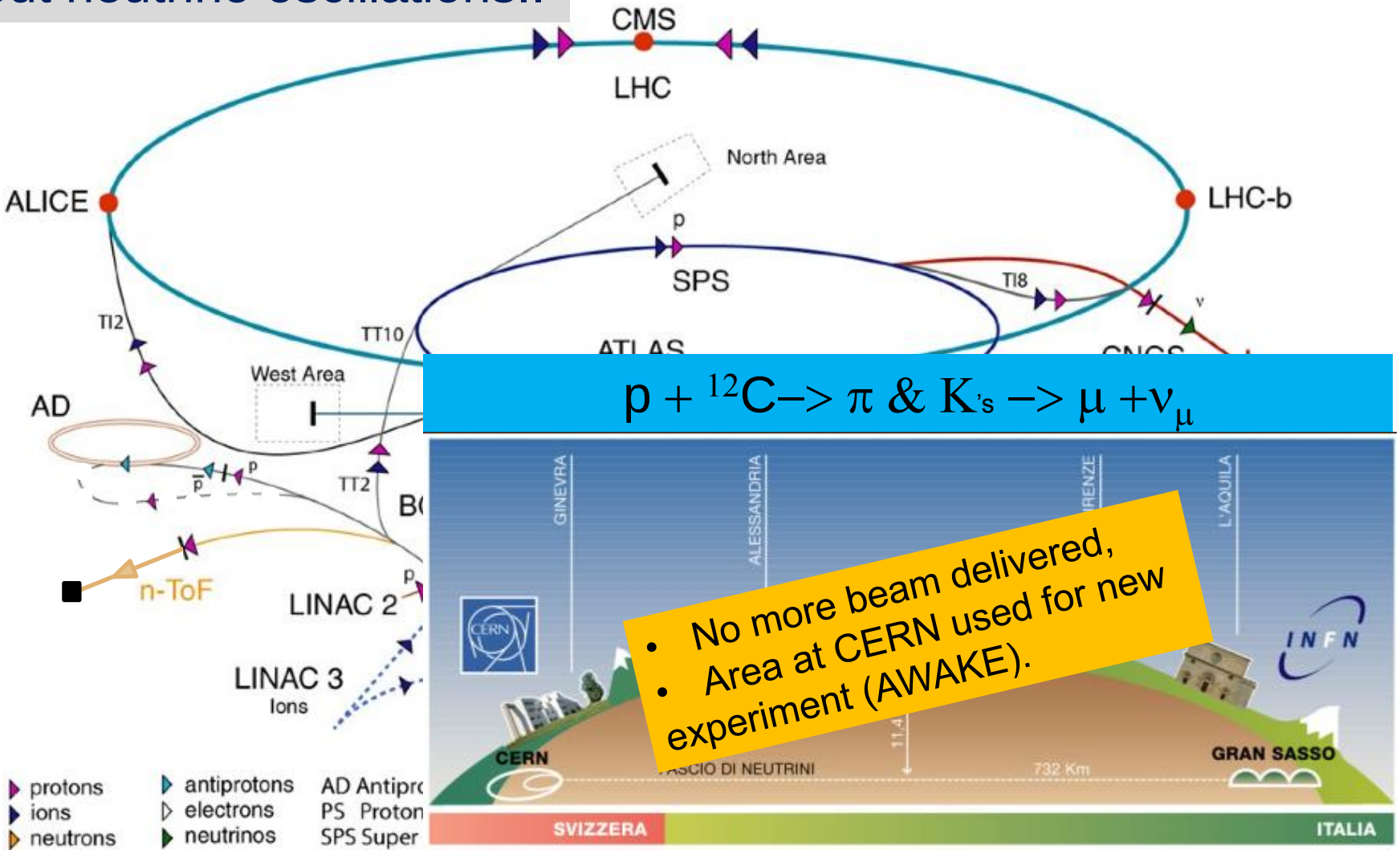
New project: ELENA (will start 2017/18)



- Dramatically slows down the antiprotons from the AD
- Increases the trapping efficiency x 100
- Allows 4 experiments to run in parallel

CERN Accelerator Complex

About neutrino oscillations..

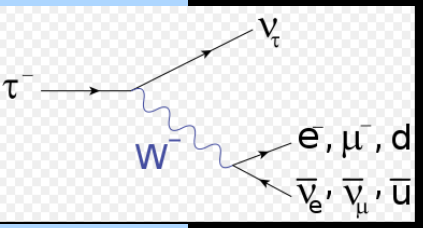


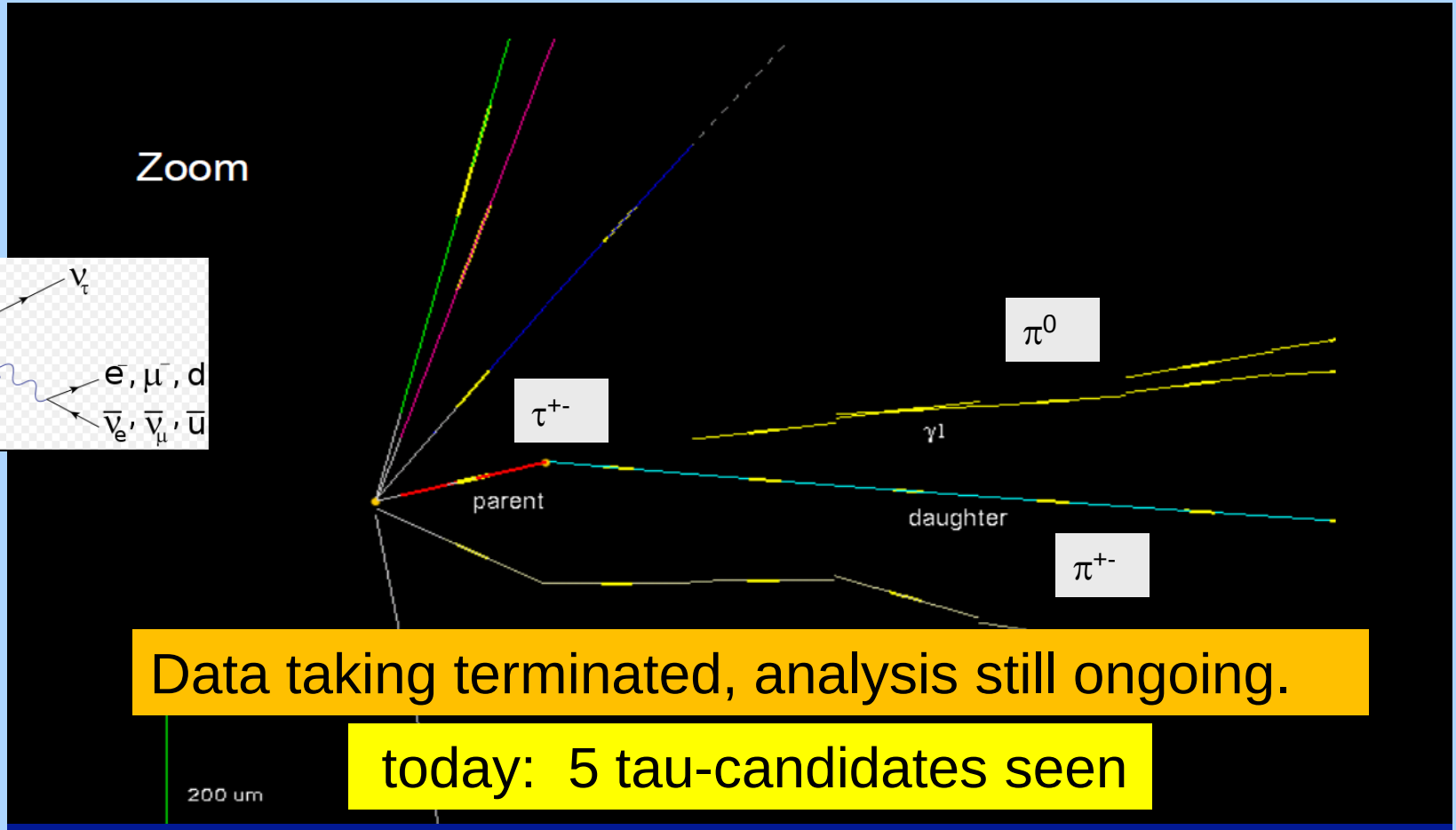
$p + {}^{12}C \rightarrow \pi \;\&\; K^{0}_{s} \rightarrow \mu + \nu_{\mu}$

- No more beam delivered,
- Area at CERN used for new experiment (AWAKE).

CNGS - OPERA

First υ_τ Candidate





Data taking terminated, analysis still ongoing.

today: 5 tau-candidates seen

Muonless event 9234119599, taken on 22 August 2009, 19:27 (UTC)
(as seen by the electronic detectors)

The Particle Physics Landscape at CERN

High Energy Frontier

LHC

Hadronic Matter

deconfinement
non-perturbative QCD
hadron structure

Low Energy

heavy flavours / rare decays
neutrino oscillations
anti-matter

Non-accelerator

dark matter
astroparticles

Multidisciplinary

climate, medicine

Non-LHC Particle Physics = o(1000) physicists / o(20) experiments

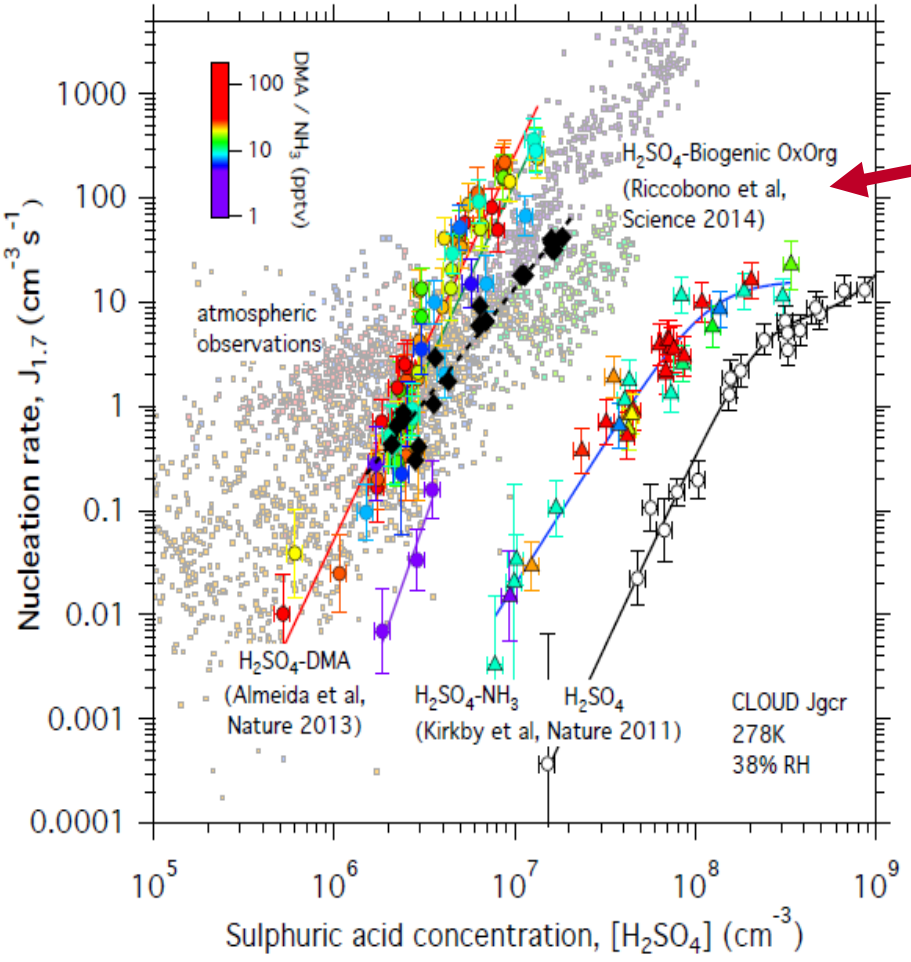
Scientific Diversity at **unique facilities**

CERN maintains and upgrades these facilities

Complemented and supported by Theory

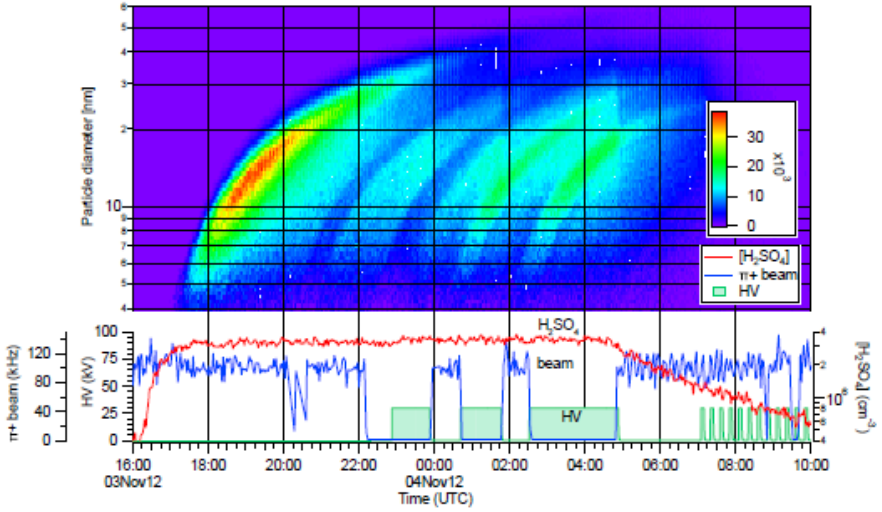
CLOUD: multidisciplinary

Formation and growth of aerosol particles in the atmosphere and their interaction with clouds.



Nucleation depends on traces of organic vapors and is sensitive to cosmic rays ionization

- Significant enhancement of ions depending on vapours and conditions:



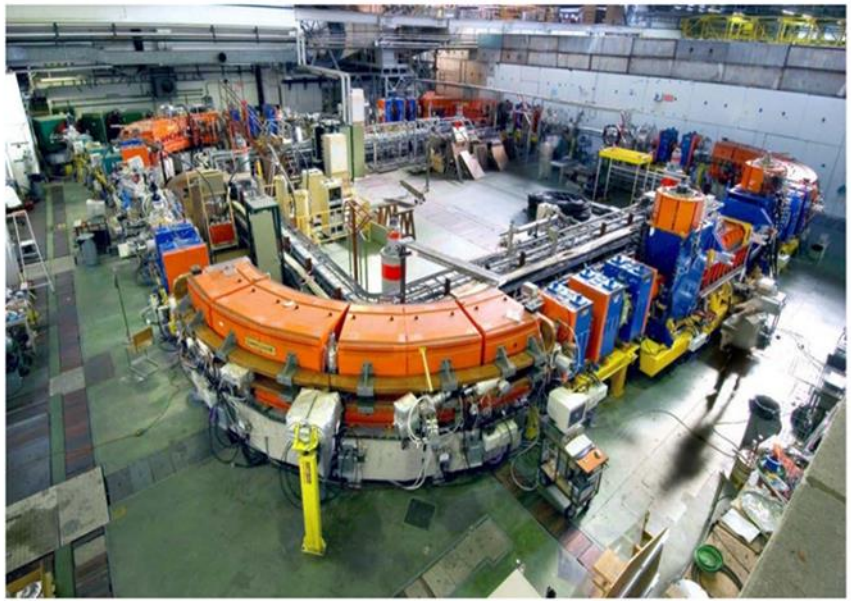
Main nucleation vapours established (H2SO4, NH3, amines (Dimethylamine (DMA)), oxidised biogenic (mostly emitted by vegetation) vapours)

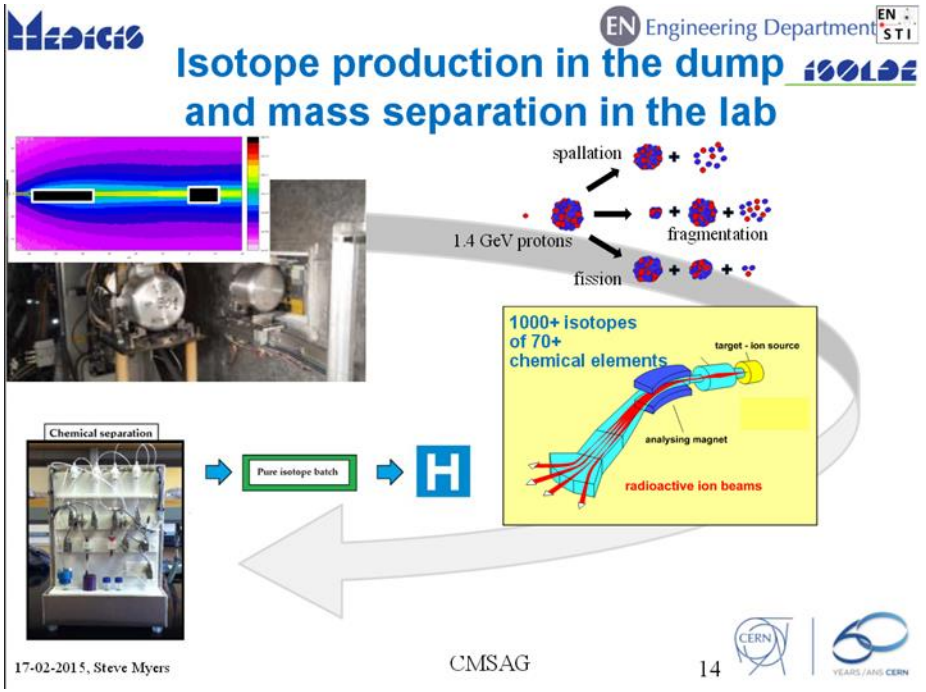
The New (2014) CERN Medical Initiatives

1. Medical Accelerator Design
   - coordinate an international collaboration to design a new compact, cost-effective accelerator facility, using the most advanced technologies
2. Biomedical Facility
   - creation of a facility at CERN that provides particle beams of different types and energies to external users for radiobiology and detector development
   - Iterative experimental verification of simulation results
3. Detectors for beam control and medical imaging
4. Diagnostics and Dosimetry for control of radiation
5. Radio-Isotopes (imaging and treatment)
6. Large Scale Computing (large data transfers and analysis, treatment planning and simulations)
7. Applications other than cancer therapy

The New (2014) CERN Medical Initiatives

Biomedical Research Facility at LEIR





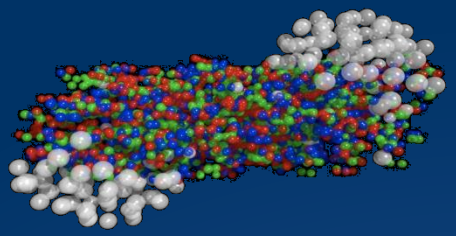
Will be carried out in a global international collaboration

High Energy Frontier

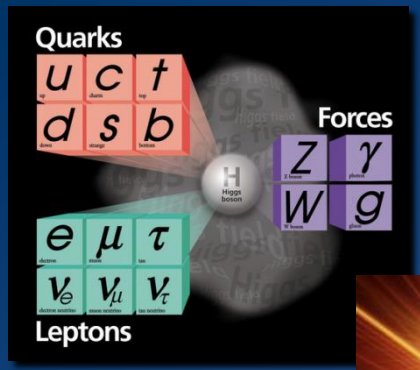
LHC

The study of LHC data will allow us to answer some of the key questions ...

Will we understand the primordial state of matter after the Big Bang before protons and neutrons formed?



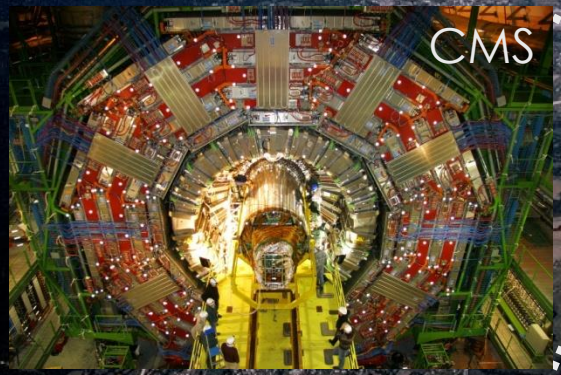
We have found the Higgs particle. What are its properties?



Will we find the reason why antimatter and matter did not completely destroy each other?

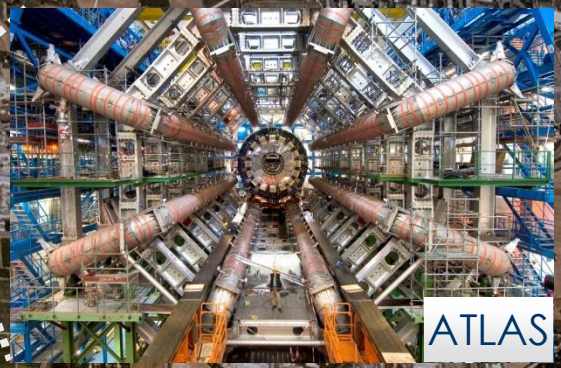
Will we find the particle(s) that make up the mysterious 'dark matter' in our Universe? And what's 'dark energy'?

2010: a New Era in Fundamental Science



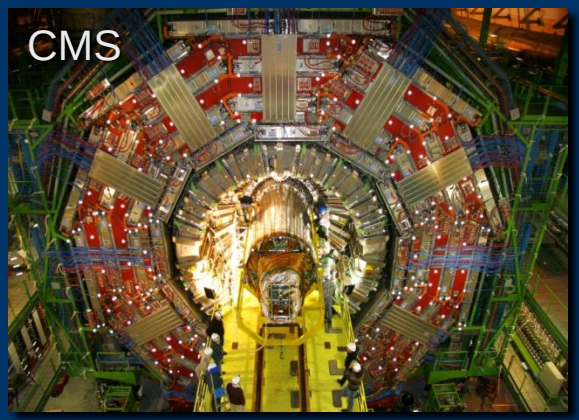
LHC ring:
27 km circumference

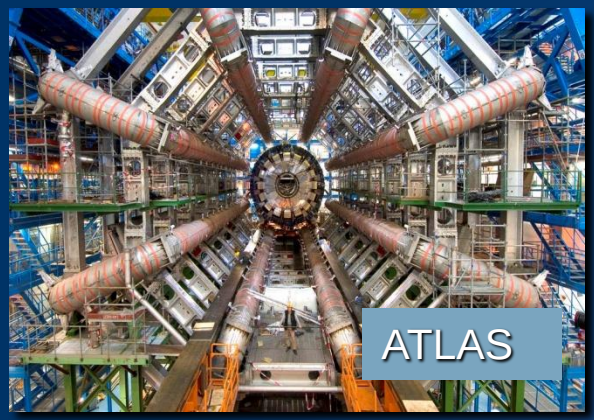
Exploration of a new energy frontier
Proton-Proton and Heavy Ion collisions
at E_{CM} up to 7 TeV



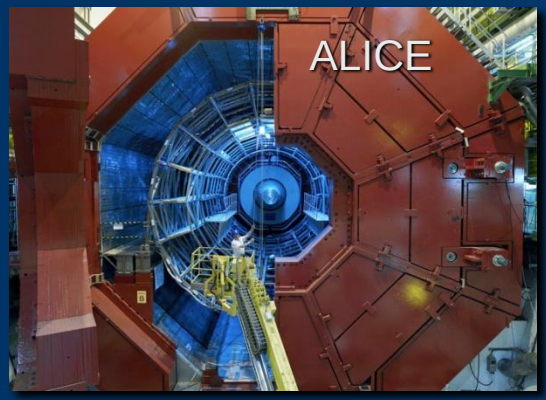
LHC Experiments → complementary

Specialised detector to study CP violation on b quarks





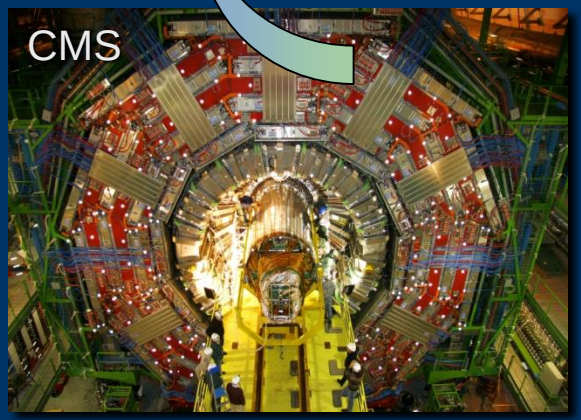
General purpose detectors

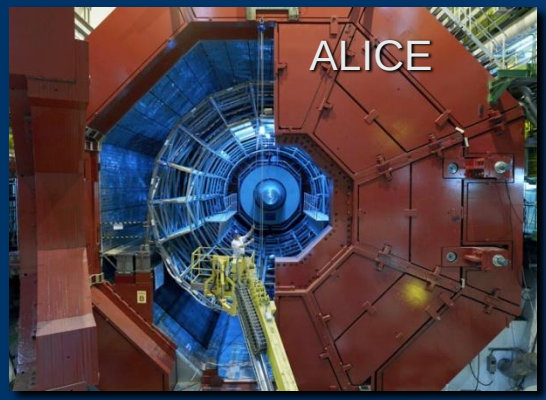


Specialised detector to study heavy ion collisions

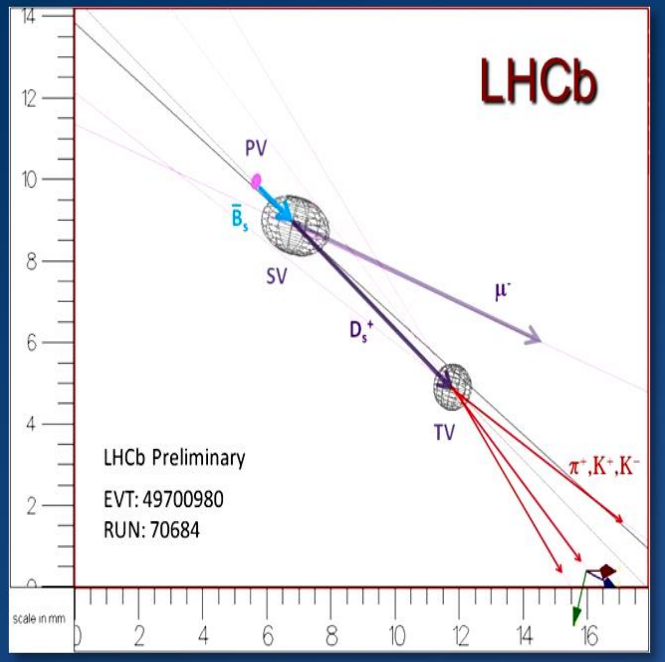
LHC Experiments → complementary

Overlap in physics reach



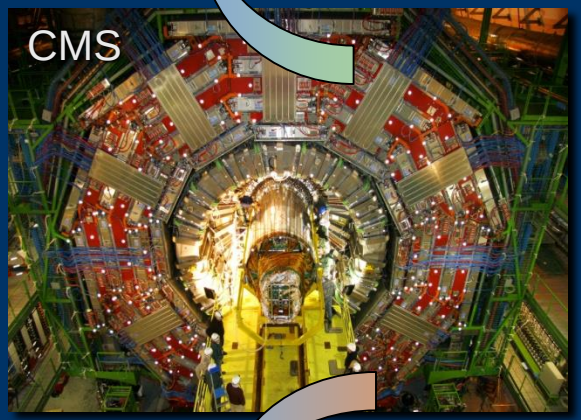


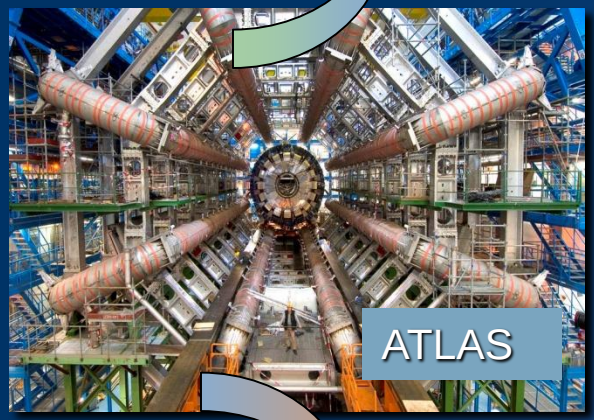
Key feature: reconstruct secondary vertex



LHC Experiments → complementary

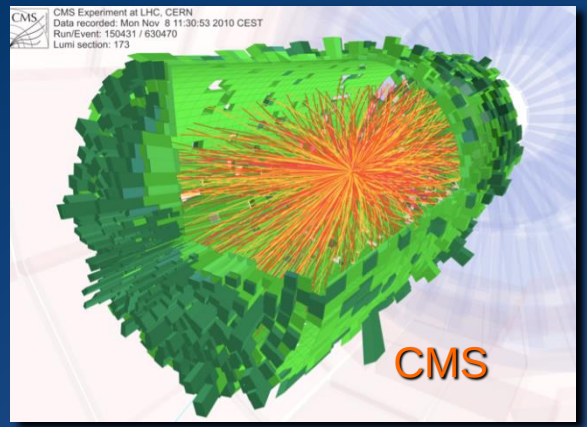
Overlap in physics reach

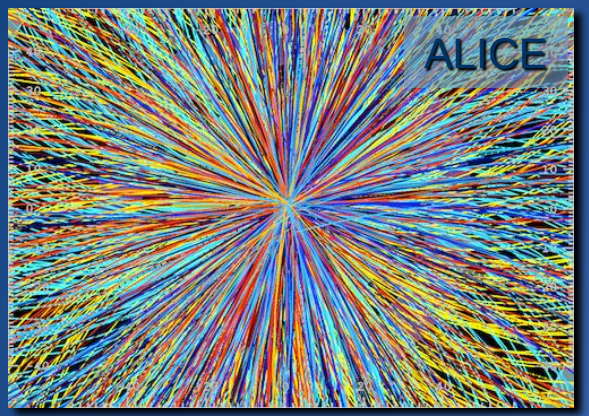




Overlap in physics reach

Key feature: reconstruct > 20'000 charged tracks in one event





Main results from LHC Run-1

1) Machine, detectors and computing performed extremely well, essentially from the start. Collisions modes: p-p / Pb-Pb / p-Pb

2) We have **consolidated** the Standard Model
(wealth of measurements at 7-8 TeV, including the rare B_s → μμ decay, very sensitive to New Physics)
→ it works BEAUTIFULLY …

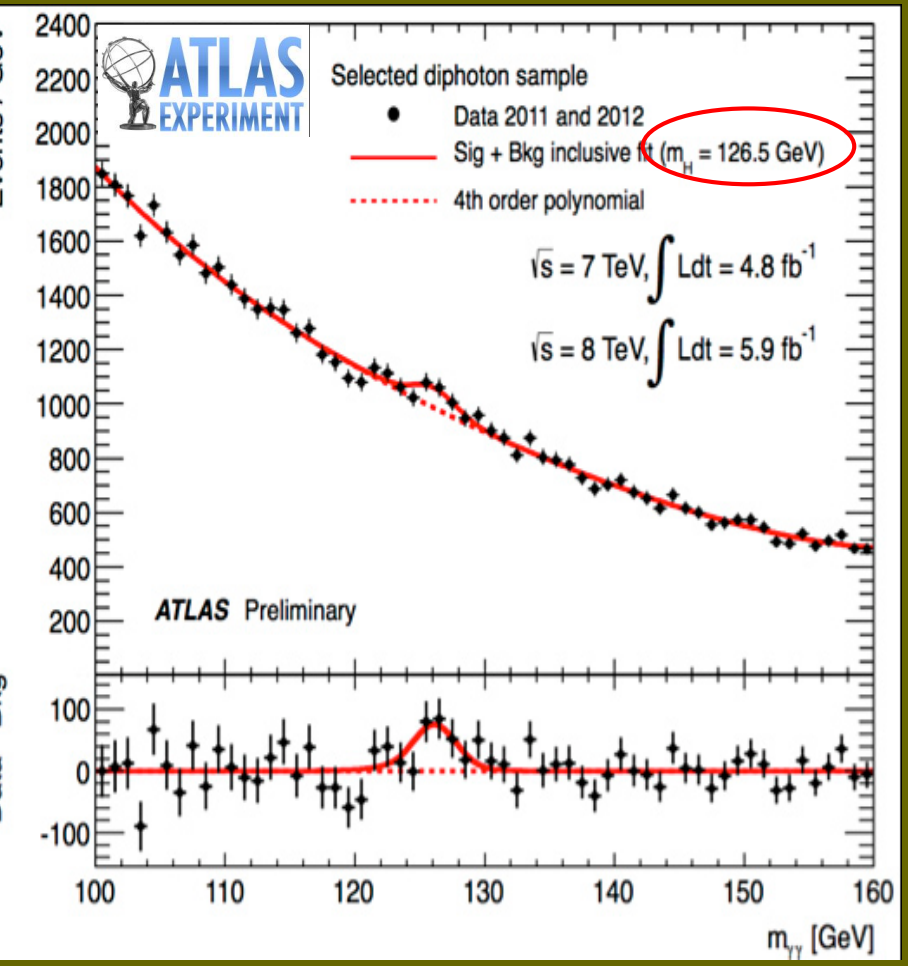
3) We have **completed** the Standard Model: Discovery of the messenger of the BEH-field, the Higgs boson discovery
(over 50 years of theoretical and experimental efforts !)

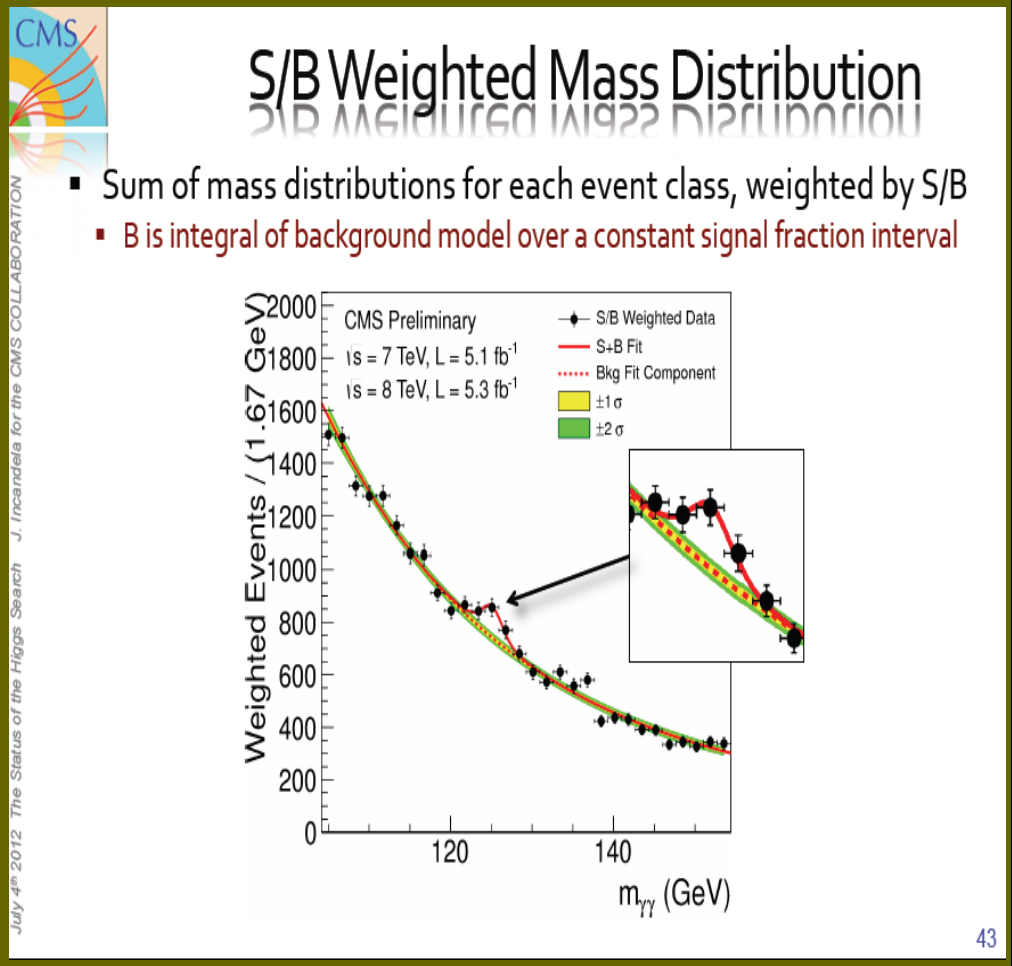
……confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".

4) We have no evidence of new physics (YET)

5) More and better…….. by D. Denegri. In particular Run-2.

Seminar July 4, 2012
ATLAS and CMS had convincing arguments……



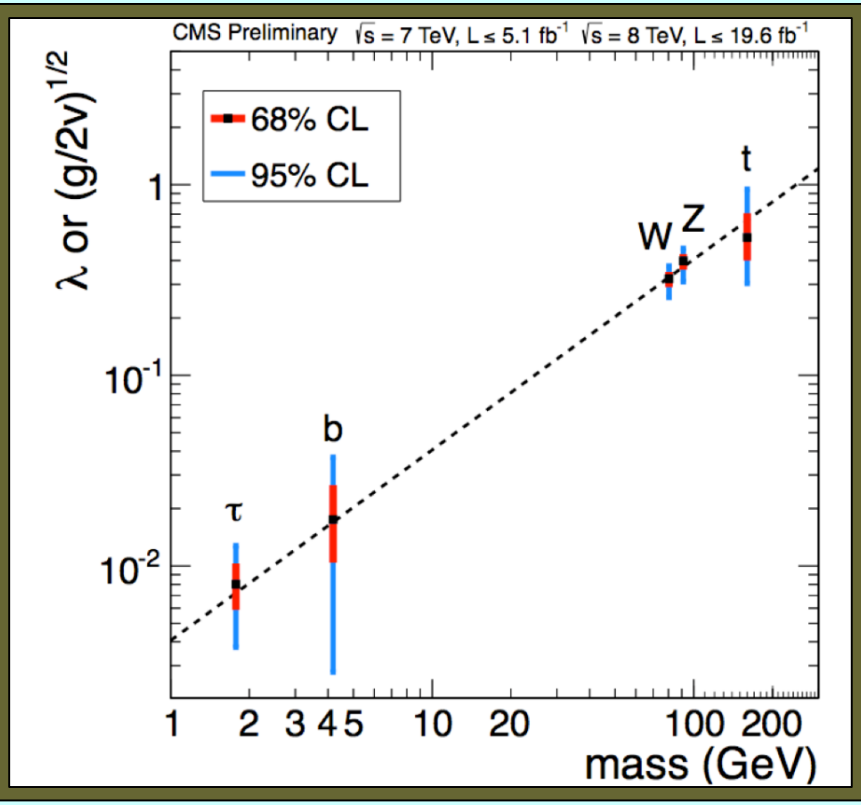


Is the new particle a Higgs boson ?

ATLAS and CMS have verified the two “fingerprints”

YES !

1) To accomplish its job (providing mass)
it interacts with other particles (in particular W, Z)
with strength proportional to their masses



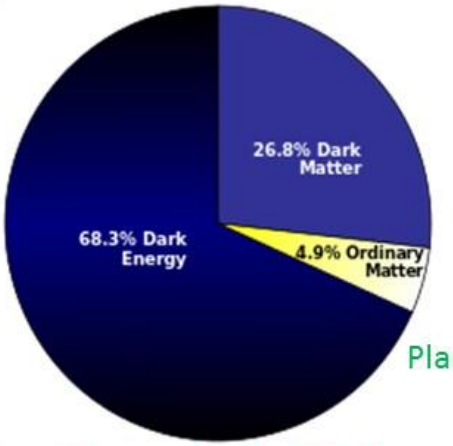
2) It has spin 0, it is representing a scalar field

It completes the Standard Model.

Thus describing ~5% of the Universe

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!

What's beyond? BSM

Different theories exist. They may:

- solve the hierarchy problem in a *natural* way
- connect the mechanisms that create the matter-over-antimatter asymmetry in the Universe, with those generating Dark Matter
- explain why there are ‘similar’ amounts of visible and dark matter in the Universe

CERN

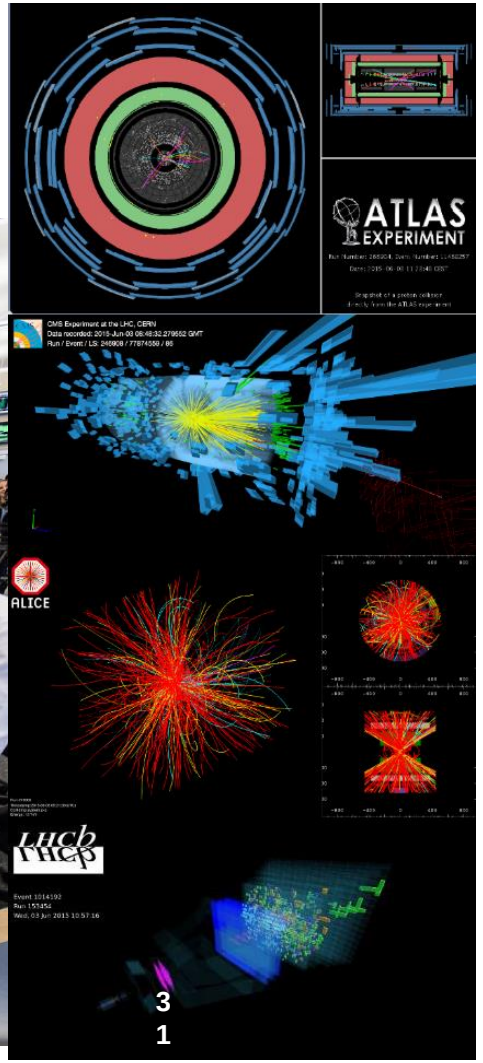
The Higgs could interact also with SUSY particles

This would change its properties

Measure all properties of the Higgs-Boson precisely

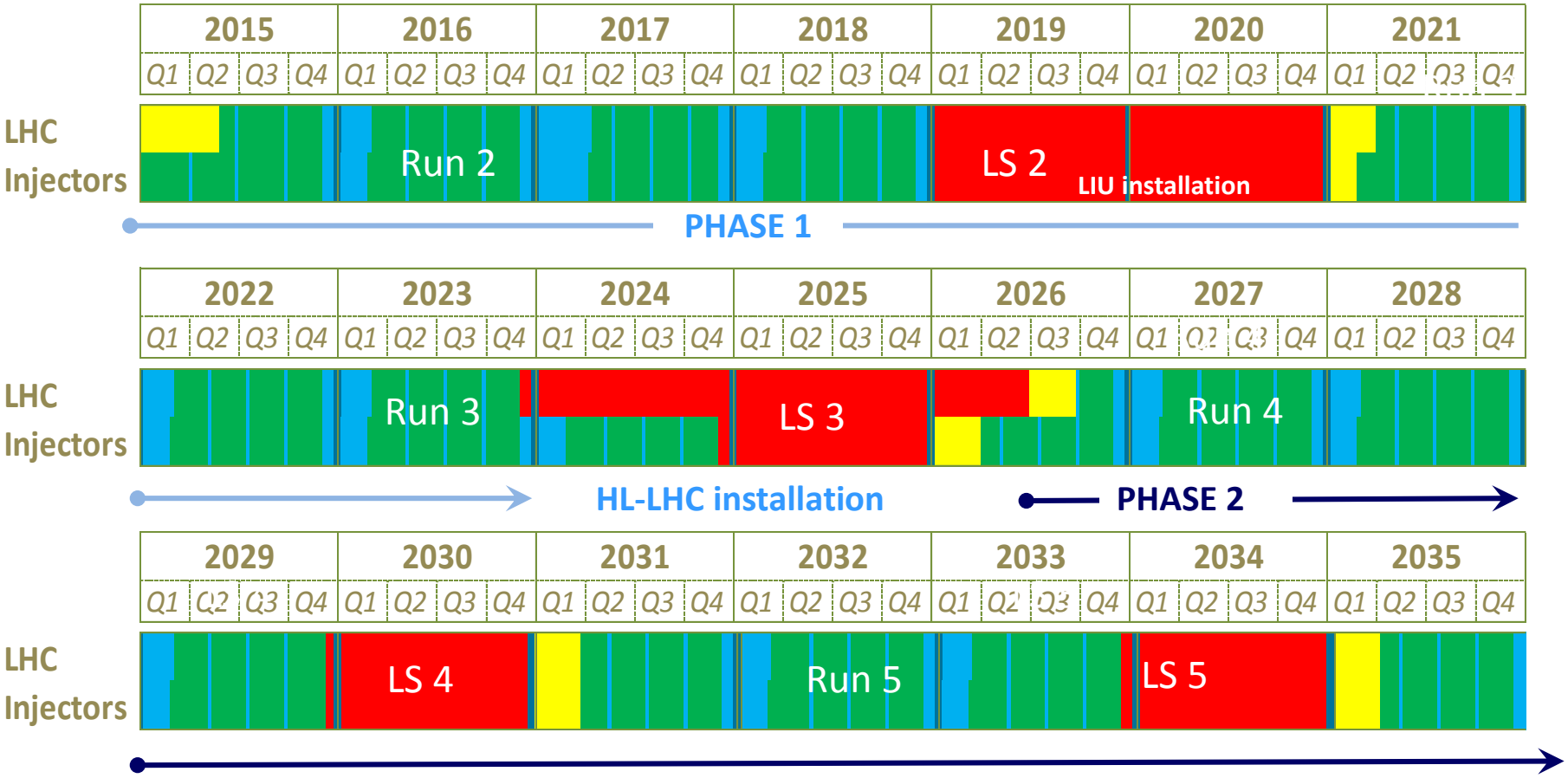
LHC experiments are back in business at a new record energy **13 TeV**

3rd June 2015



LHC roadmap

LS2 starting in 2019 => 24 months + 3 months BC
LS3 LHC: starting in 2024 => 30 months + 3 months BC
Injectors: in 2025 => 13 months + 3 months BC



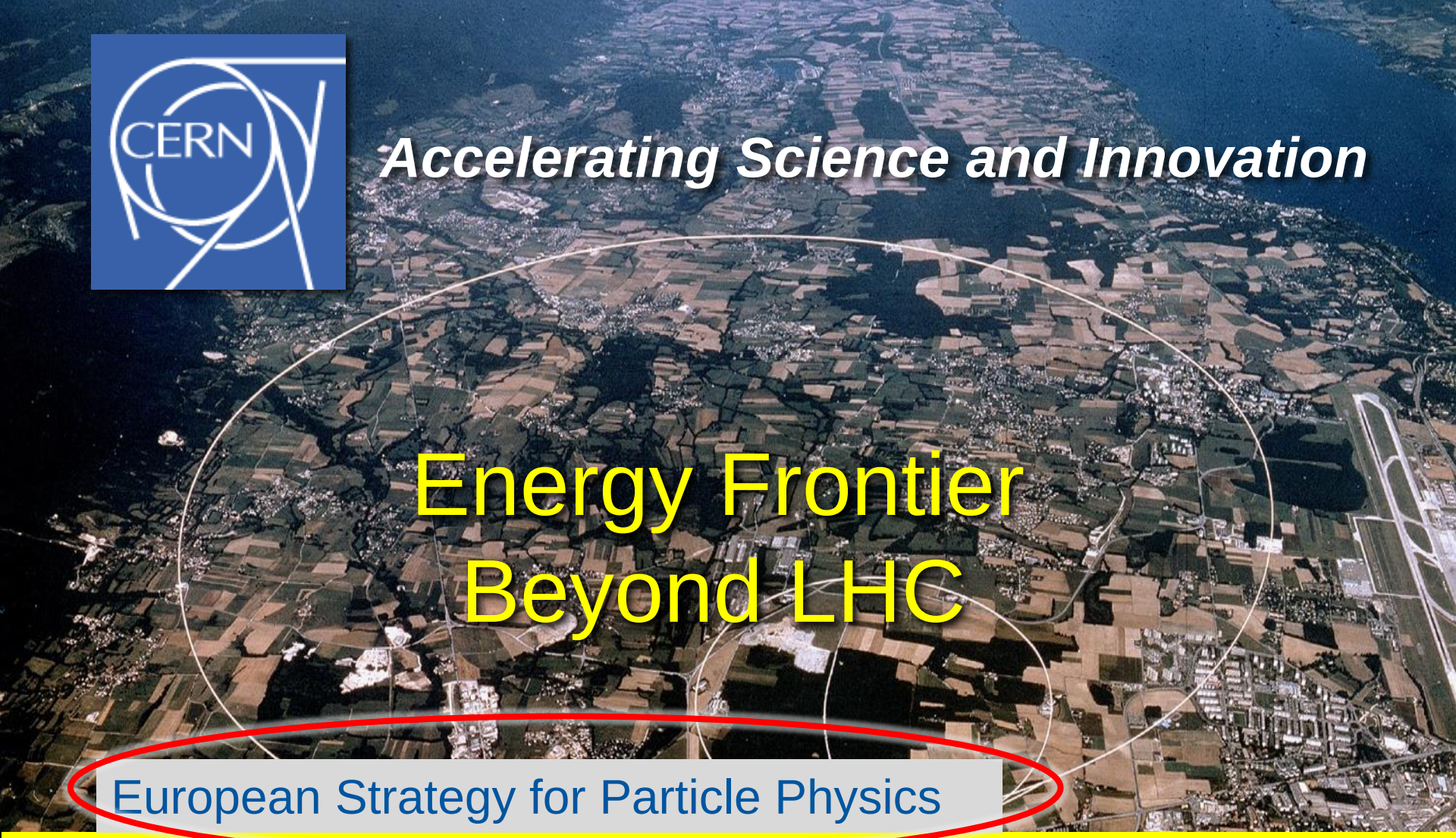
LIU: LHC Injectors upgrade

LHC

Key message

There is a ... ntier
... TeV (essentially done)
14 TeV design luminosity
14 TeV high luminosity (HL-LHC)

Upgrades to accelerator complex, detectors, and computing Grid are vital to fully exploit the physics potential of LHC



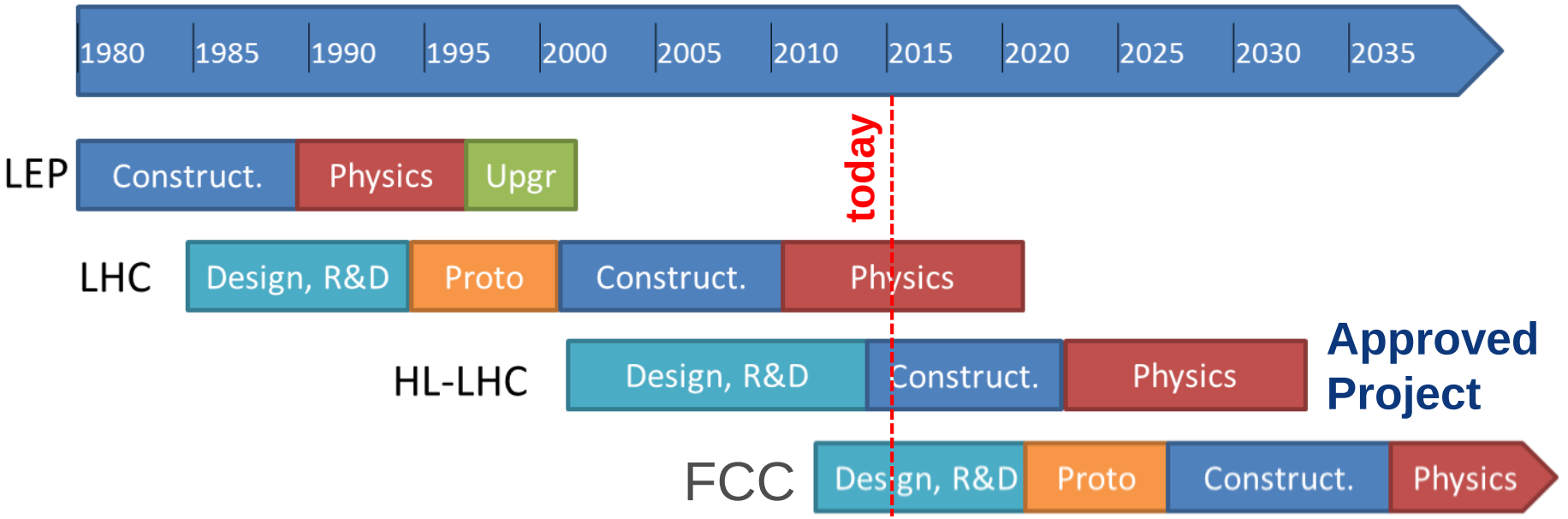
Energy Frontier Beyond LHC

European Strategy for Particle Physics

Four high-priority large-scale scientific activities identified:

1) full potential of LHC (incl. Hi-Lumi) – almost done.
2) Post-LHC accelerator at CERN (FCC, CLIC)
3) e^+e^- collider
4) Long-baseline neutrino project (US, Japan,…)

*European Strategy: "CERN should undertake design studies for accelerator projects in a global context, with emphasis on **proton-proton** and electron- positron **high-energy frontier machines**."*



FCC (Future Circular Colliders) Studies : p-p towards 100 TeV

- **Kick-off meeting: February 2014 (Univ. Geneva)**
- **1st collaboration meeting March 2015 (Washington)**
- **…..**

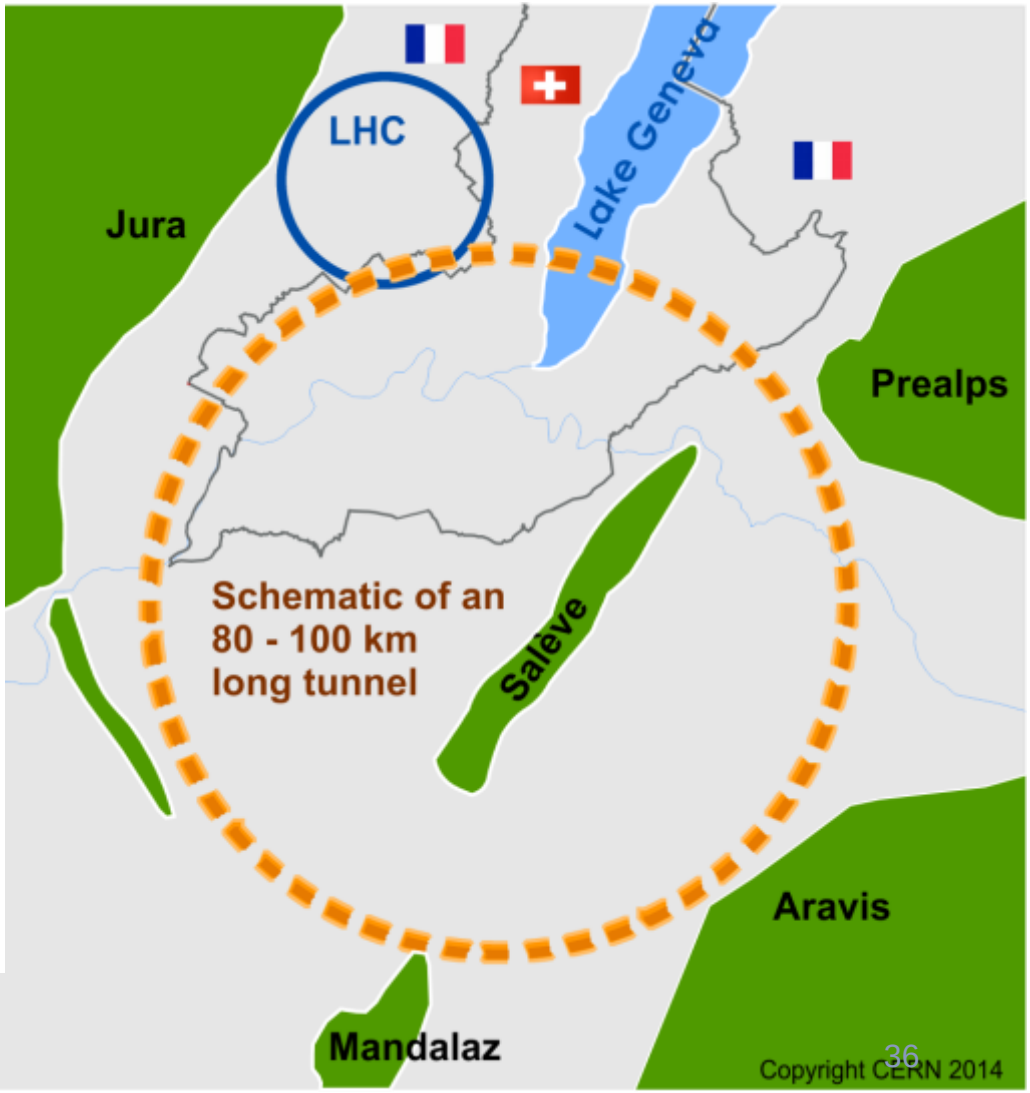
Future Circular Collider Study - SCOPE
CDR and cost review for the next European Strategy Update (2018)

Forming an international collaboration to study:

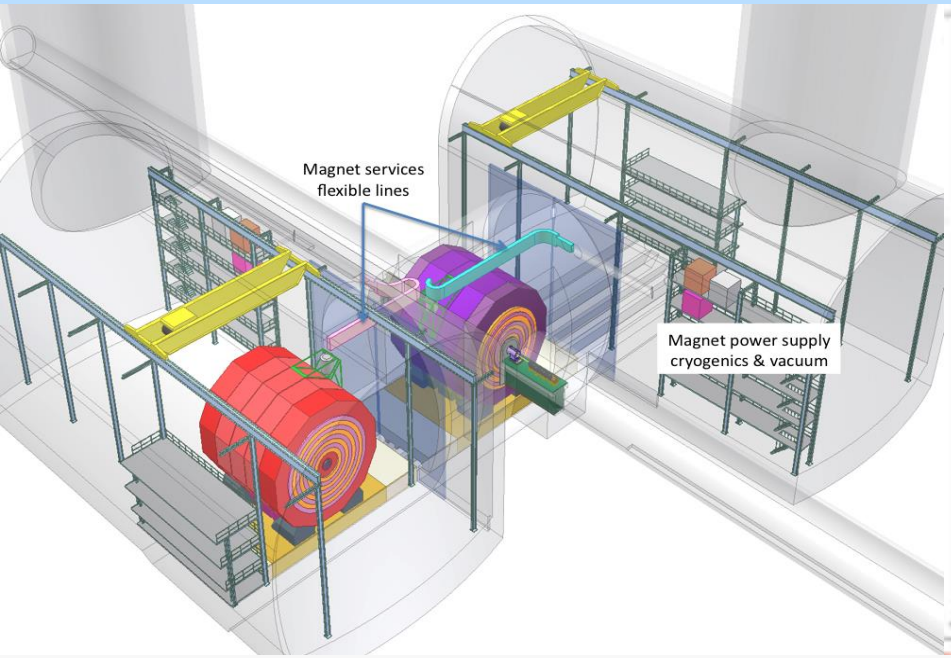
- ***pp*-collider (*FCC-hh*)**
  → defining infrastructure requirements

~16 T ⇒ 100 TeV *pp* in 100 km
~20 T ⇒ 100 TeV *pp* in 80 km

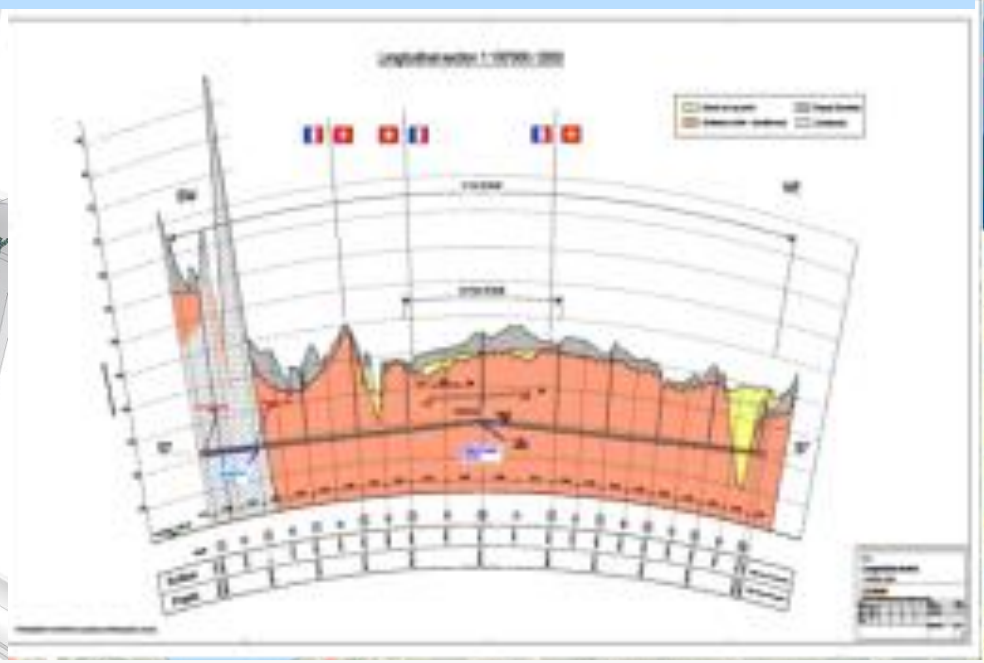
- **e^+e^- collider (*FCC-ee*)** as potential intermediate step
- *p-e* (*FCC-he*) option
- **80-100 km infrastructure** in Geneva area



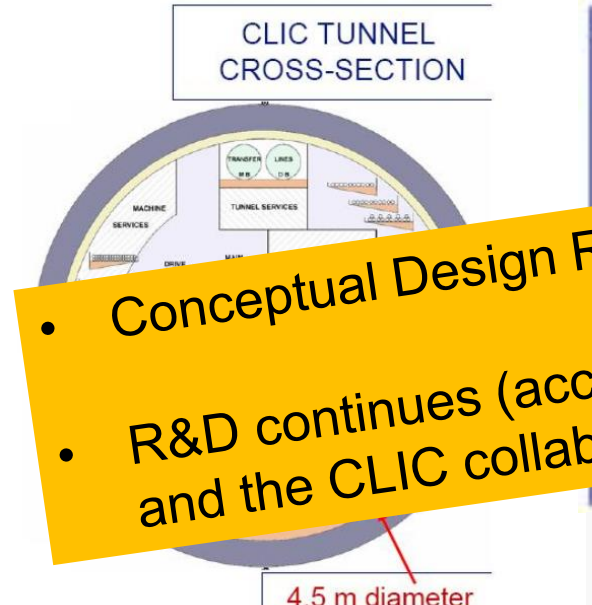
CLIC near CERN

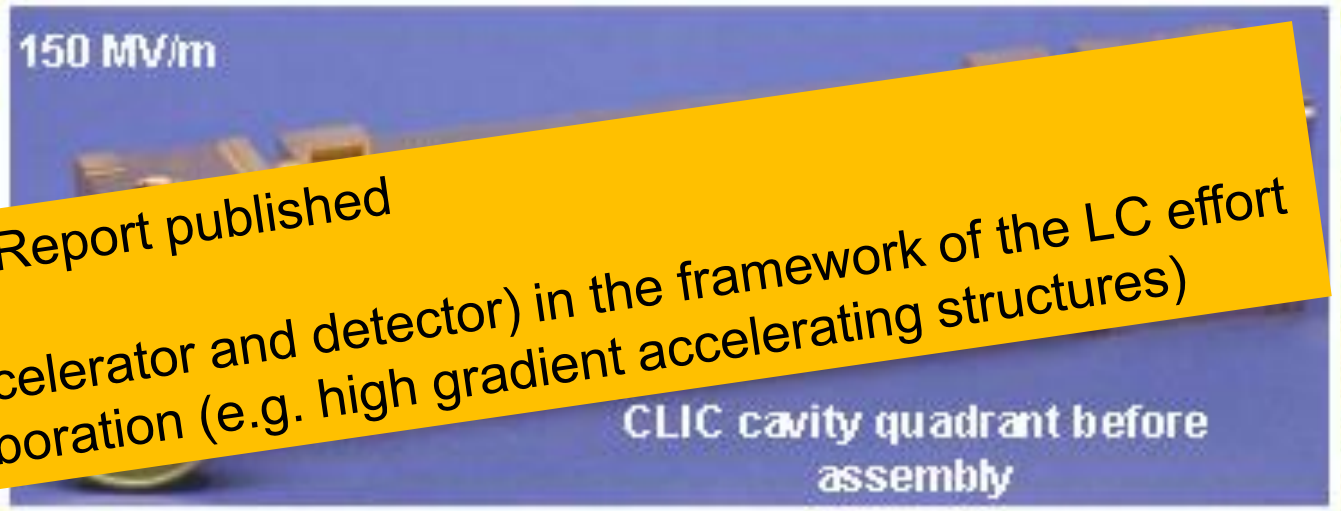


Central MDI & Interaction Region



Tunnel implementation studies





- Conceptual Design Report published
- R&D continues (accelerator and detector) in the framework of the LC effort and the CLIC collaboration (e.g. high gradient accelerating structures)

Needs very high accelerating gradients, typ. 100MV/m – Tests in progress

European Strategy for Particle Physics

Four high-priority large-scale scientific activities identified:

1) full potential of LHC (incl. Hi-Lumi)
2) Post-LHC accelerator at CERN (FCC, CLIC)
3) e^+e^- collider
4) Long-baseline neutrino project (US, Japan,…)

3) There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision and whose energy can be upgraded. The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation. The initiative from the Japanese particle physics community to host the ILC in Japan is most welcome, and European groups are eager to participate. ***Europe looks forward to a proposal from Japan to discuss a possible participation.***

- At CERN ILC efforts continue in the framework of the LC efforts.

4)

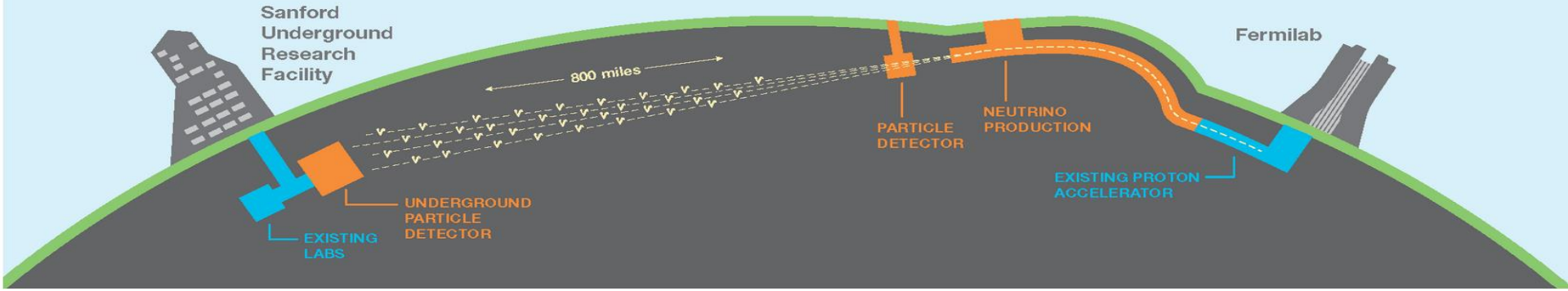
Neutrino Platform

Create a platform to pave the way for a European contribution in a neutrino facility in the US or Asia (part of the European Strategy for Particle Physics)

Financial scenario with an allocation to allow for

- Extension of the experimental area of the SPS complex (North Area)
- (liquid argon) detector R&D for neutrino experiments
- Preparing detectors at CERN for transport to US

- DUNE (Deep Underground Neutrino Experiment) project
- Highest-intensities ever. Distance twice CNGS.



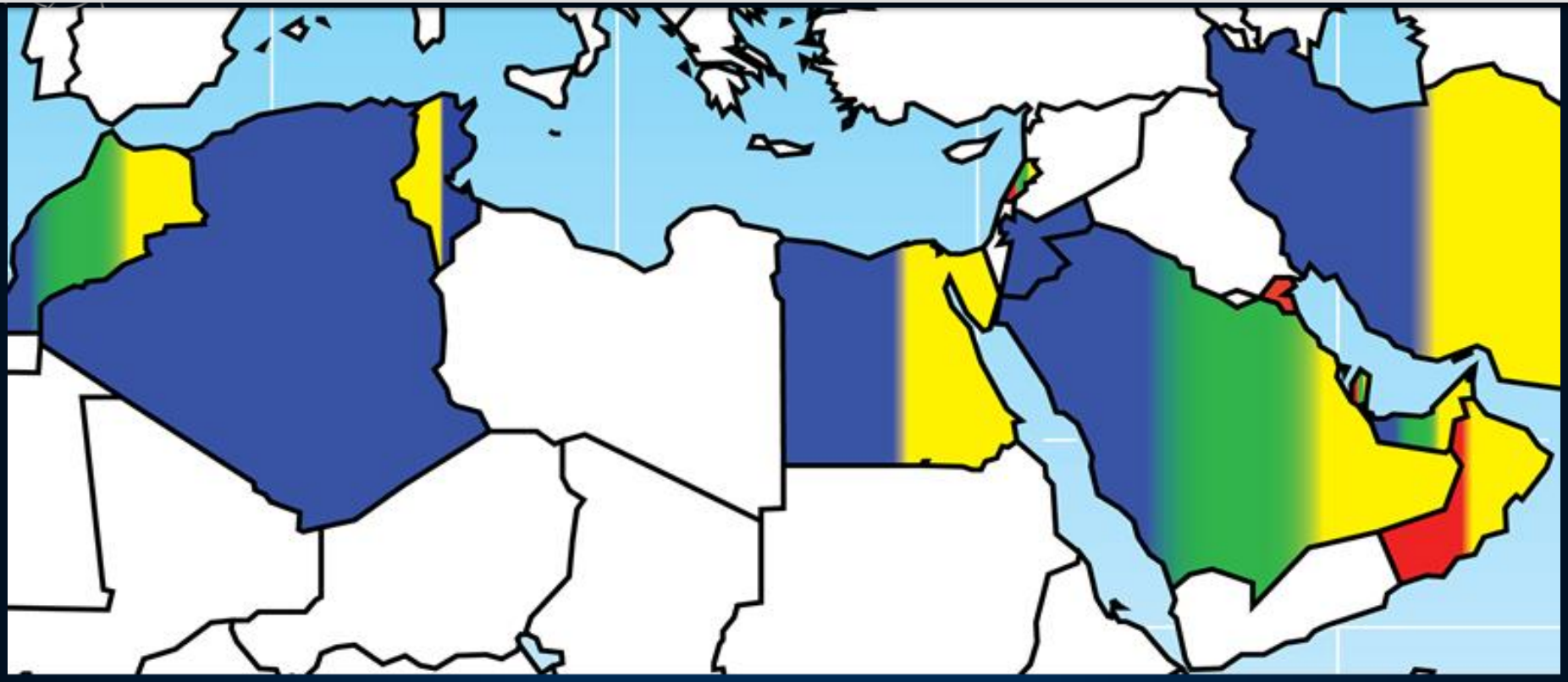
With the European Strategy, approved by Council May 2013, with the P5 recommendations, approved by HEPAP in the US, with the Japanese roadmap

we have (for the first time) a global vision for our field going beyond regional boundaries

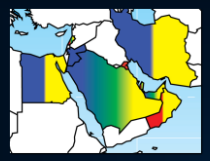
CERN is playing a major role in this global endeavour

HEPAP: High Energy Physics Advisory Panel

4. Collaboration with CERN – Focus on MENA



- Governmental Co-operation Agreements: Algeria, Egypt, Iran, Jordan (SESAME), Morocco, Saudi Arabia, Tunisia, U.A.E. Next: Lebanon
- Other scientific contacts: Bahrain, Kuwait, Lebanon, Oman, Palestine, Qatar
- Teachers programme: Lebanon, Qatar, Saudi Arabia, U.A.E.
- Summer Student Programme: Bahrain, Egypt, Iran, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, UAE



MENA – CERN Collaboration

- CERN is open to collaboration with qualified and interested scientists from any country
  - Co-operation agreements with governments of Algeria, Egypt, Iran, Jordan, Lebanon (Dec. 2015), Morocco, Saudi Arabia, Tunisia(signed 13.05.2014), UAE.
  - Contacts with individual scientists from many others (Lebanon, Oman, Palestinian Authority, Qatar….)
- CERN provides access to training programmes to help capacity-building
  - Physics, engineering, information technology
  - Summer students, high-school teachers, …
- Open access to scientific information
  - Training in digital library techniques
- Exhibitions. Egypt (Alessandria), Morroco, Tunisia….
- UNESCO offers support through IBSP (*). What about ISESCO (OIC) ?

(*) International Basic Sciences Programme

Looking forward to expanded collaboration with **MENA**

Egypt and CERN

January 2006	Signature of International Co-operation Agreement during visit to Egypt by former CERN DG Robert Aymar
May 2006	Visit to CERN by former Minister Hany Helal
Sept. 2008	Visit to CERN by Prof. Tarek Hussein, former President of the Academy of Science, Research & Technology
June 2010	Multi-university group joined **CMS** Collaboration
Sept. 2010	Visit to CERN by Prof. Maged El Sherbiny, President of the Academy of Science, Research & Technology
March 2011	Interest in participating in **ALICE** experiment via JINR, Dubna
May 2011	Visit to CERN by A. Ezzat Salama**,** Minister for Scientific Research, Science and Technology
23 May 2012	Visit to CERN by Dr Nadia Eskndar Zkhary, Minister of Scientific Research
2 October 2012	Signatures of the Protocol to ICA, ALICE MoU and CMS MoU
December 2013	Donation by CERN of > 100 servers to make a Tier2 center

Robert Aymar and Minister Hany Helal
May 2006

Minister A. Ezzat Salama, May 2011

Minister N. Eskndar Zkhary, May 2012

Egypt-Contributions to ALICE (present/future plan)

- **Physics:**
  - **Data Analysis: Light-Flavor**
- **Computation:**
  - **Task Scheduling Algorithms on Grid-Computing Systems**
- **Electronics:**
  - **Low Power 2Gbps LVDS Driver**

Absolved Trainings:

1. **Ehab G. Abbas, Hend Magdy Baza, Abdel Magied Diab, Nada Ezzelarab, Rabie Ramadan and Abdel Nasser Tawfik (Physics)**
2. **Ahmed Soudi (Computer Science)**
3. **Ahmed Saied (Electronics)**

- **Examples on Publications?**

1. Performance of the ALICE VZERO system, ALICE Collaboration (Ehab Abbas et al.), JINST 8 (2013) P10016.
2. Mid-rapidity anti-baryon to baryon ratios in pp collisions at 0.9, 2.76 and 7 TeV measured by ALICE, ALICE Collaboration (Ehab Abbas et al.), Eur.Phys.J. C73 (2013) 2496.
3. Charmonium and e^+ e^- pair photoproduction at mid-rapidity in ultra-peripheral Pb-Pb collisions at 2.76 TeV, ALICE Collaboration (Ehab Abbas et al.), Eur.Phys.J. C73 (2013) 11, 2617.
4. Centrality dependence of the pseudorapidity density distribution for charged particles in Pb-Pb collisions at= 2.76 TeV, ALICE Collaboration (Ehab Abbas et al.), Phys.Lett. B726 (2013) 610-622.
5. J/Psi Elliptic Flow in Pb-Pb Collisions at 2.76 TeV, ALICE Collaboration (Ehab Abbas et al.), Phys.Rev.Lett. 111 (2013) 162301

- **Other Projects:**

1. Study of prompt and secondary D-meson decay in the ALICE experiment
2. High-Momentum Charmed Mesons in the ALICE experiment
3. Angular Scaling of Jets as B- and C-Tagger









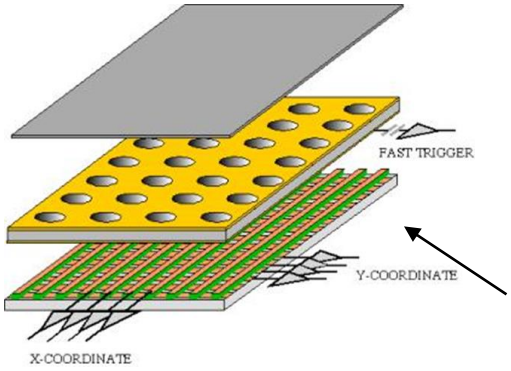

Courtesy Abdel Nasser Tawkif

Egypt activities at CMS

- ENHEP joined CMS experiment officially, as full member, in March 2010.
- 2 main contributions:

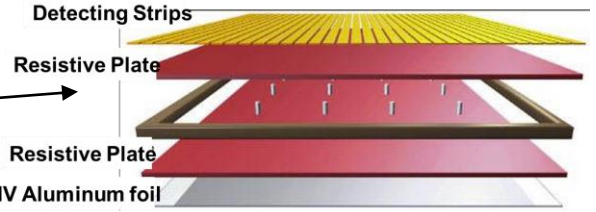
  i. **Physics analysis (Z', Higgs, Excited Muon, etc.)**

  ii. **Experimental Services (Resistive Plate Chamber (RPC) and Gas Electron Multiplier (GEM) detector)**



RPC in EC region:

- Assembly, test, QA….@ CERN
- Test stand at Helwan



GEM at high eta:

- For fast triggering

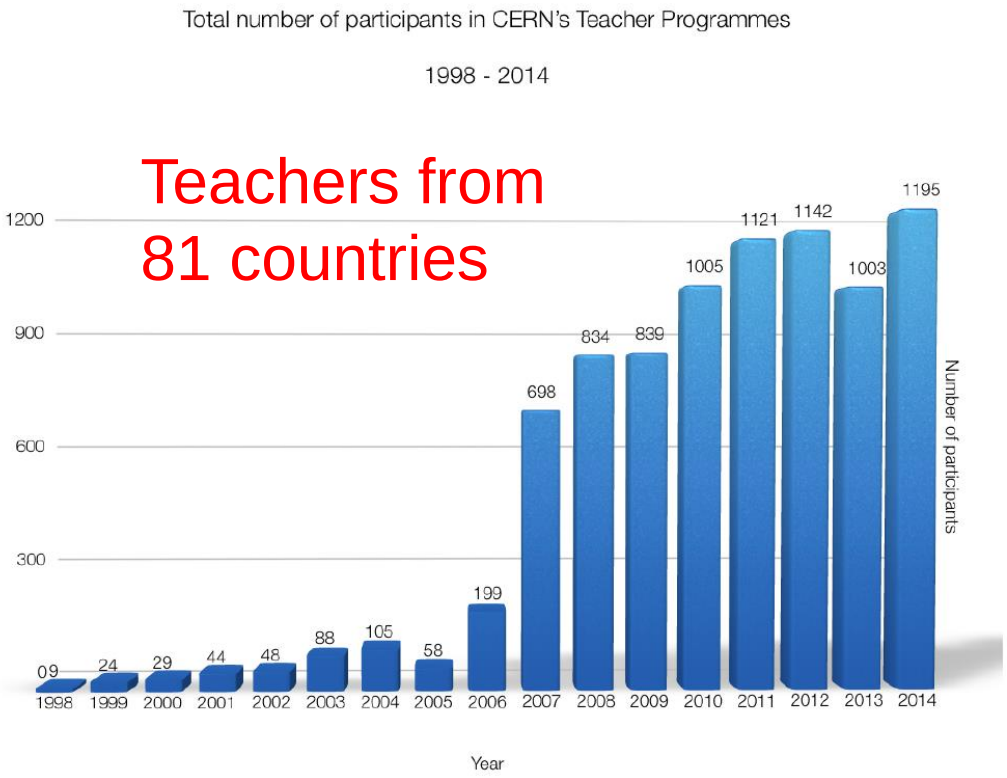
RPC setup at Helwan university

- Close to 10 publications in international peer reviewed journals

Courtesy Shaaban Khalil


CERN
Accelerating Science and Innovation
5. Beyond Science

Education and Capacity Building – Teachers programs



Teachers Programs, 2 options:

- International program (3 weeks in July), English
- Courses of one week duration in the mother language of the teachers, at CERN or remotely. Special programme for Algeria, Jan 2016.

CERN Teacher Programme

Teacher Programme Participants 1998 - 2014 (Total: 8430)

MEMBER STATES

Austria	154
Belgium	122
Bulgaria	375
Czech Republic	153
Denmark	132
Finland	472
France	282
Germany	842
Greece	574
Hungary	407
Israel	44
Italy	403
Netherlands	126
Norway	105
Poland	579
Portugal	361
Slovakia	221
Spain	402
Sweden	206
Switzerland	127
United Kingdom	1077

7164

CANDIDATE FOR ACCESSION

Romania	13
Serbia	47

60

OBSERVER STATES

India	3
Japan	6
Russia	279
Turkey	74
USA	92

454

EGYPT ??

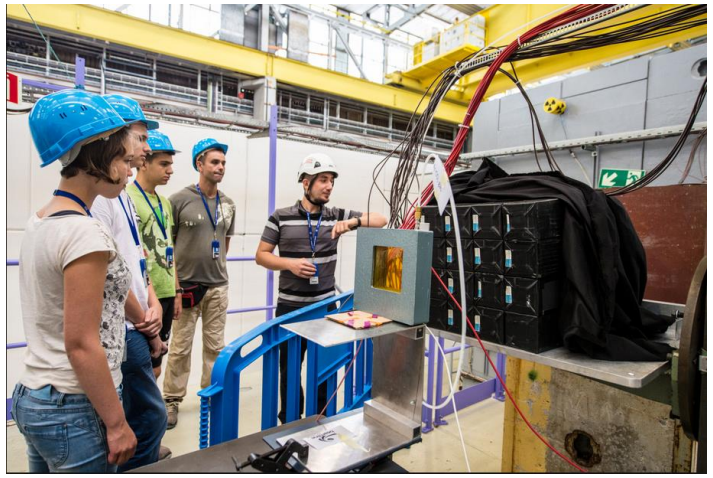
OTHERS

Angola	7	Chile	3	Ireland	7	Montenegro	13	Slovenia	21
Armenia	1	China	2	Jordan	11	Morocco	2	South Africa	6
Australia	6	Croatia	2	Kazakhstan	5	Mozambique	19	South Korea	48
Azerbaijan	1	Cyprus	8	Kenya	4	Nepal	1	Swaziland	1
Belarus	2	Dominican Rep.	24	Latvia	1	New Zealand	1	Thailand	10
Brazil	144	Ecuador	2	Lebanon	1	Palestine (O.T.)	1	T.F.Y.R.O.M.	11
Burundi	2	Estonia	54	Lithuania	16	Qatar	1	Timor-Leste	7
Cameroon	4	Georgia	88	Madagascar	2	Rwanda	20	Uganda	3
Canada	7	Ghana	6	Malta	36	Sao Tome	5	Ukraine	113
Cape Verde	4	Guinea Bissau	1	Mexico	10	Saudi Arabia	1	U.A.E.	1
		Iran	3	Mongolia	1	Singapore	2		

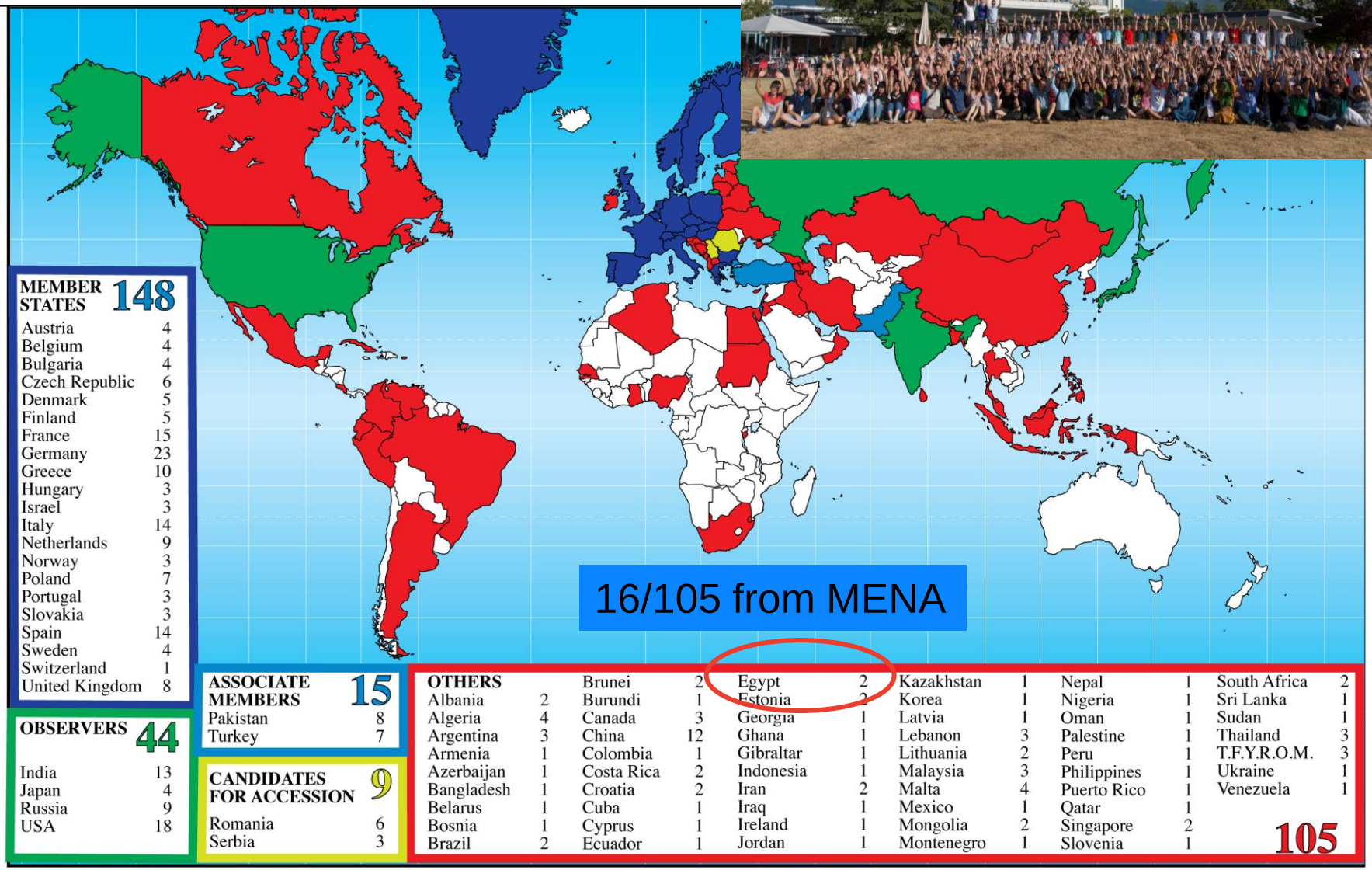
752

Education and Capacity Building for the youngsters……

- School Students Programs
  - “slip into the skin of a researcher”
  - special competitions
- High School Students Programs
  - S’Cool Lab
  - Beamline for Schools
  - Masterclasses
- Summer Students Program



Summer Students 2015



16/105 from MENA

MEMBER STATES	148
Austria	4
Belgium	4
Bulgaria	4
Czech Republic	6
Denmark	5
Finland	5
France	15
Germany	23
Greece	10
Hungary	3
Israel	3
Italy	14
Netherlands	9
Norway	3
Poland	7
Portugal	3
Slovakia	3
Spain	14
Sweden	4
Switzerland	1
United Kingdom	8

OBSERVERS	44
India	13
Japan	4
Russia	9
USA	18

ASSOCIATE MEMBERS	15
Pakistan	8
Turkey	7

CANDIDATES FOR ACCESSION	9
Romania	6
Serbia	3

OTHERS		Brunei	2	Egypt	2	Kazakhstan	1	Nepal	1	South Africa	2
Albania	2	Burundi	1	Estonia	2	Korea	1	Nigeria	1	Sri Lanka	1
Algeria	4	Canada	3	Georgia	1	Latvia	1	Oman	1	Sudan	1
Argentina	3	China	12	Ghana	1	Lebanon	3	Palestine	1	Thailand	3
Armenia	1	Colombia	1	Gibraltar	1	Lithuania	2	Peru	1	T.F.Y.R.O.M.	3
Azerbaijan	1	Costa Rica	2	Indonesia	1	Malaysia	3	Philippines	1	Ukraine	1
Bangladesh	1	Croatia	2	Iran	2	Malta	4	Puerto Rico	1	Venezuela	1
Belarus	1	Cuba	1	Iraq	1	Mexico	1	Qatar	1		
Bosnia	1	Cyprus	1	Ireland	1	Mongolia	2	Singapore	2		
Brazil	2	Ecuador	1	Jordan	1	Montenegro	1	Slovenia	1		105

GENERAL INFORMATION ABOUT THE EXHIBITION

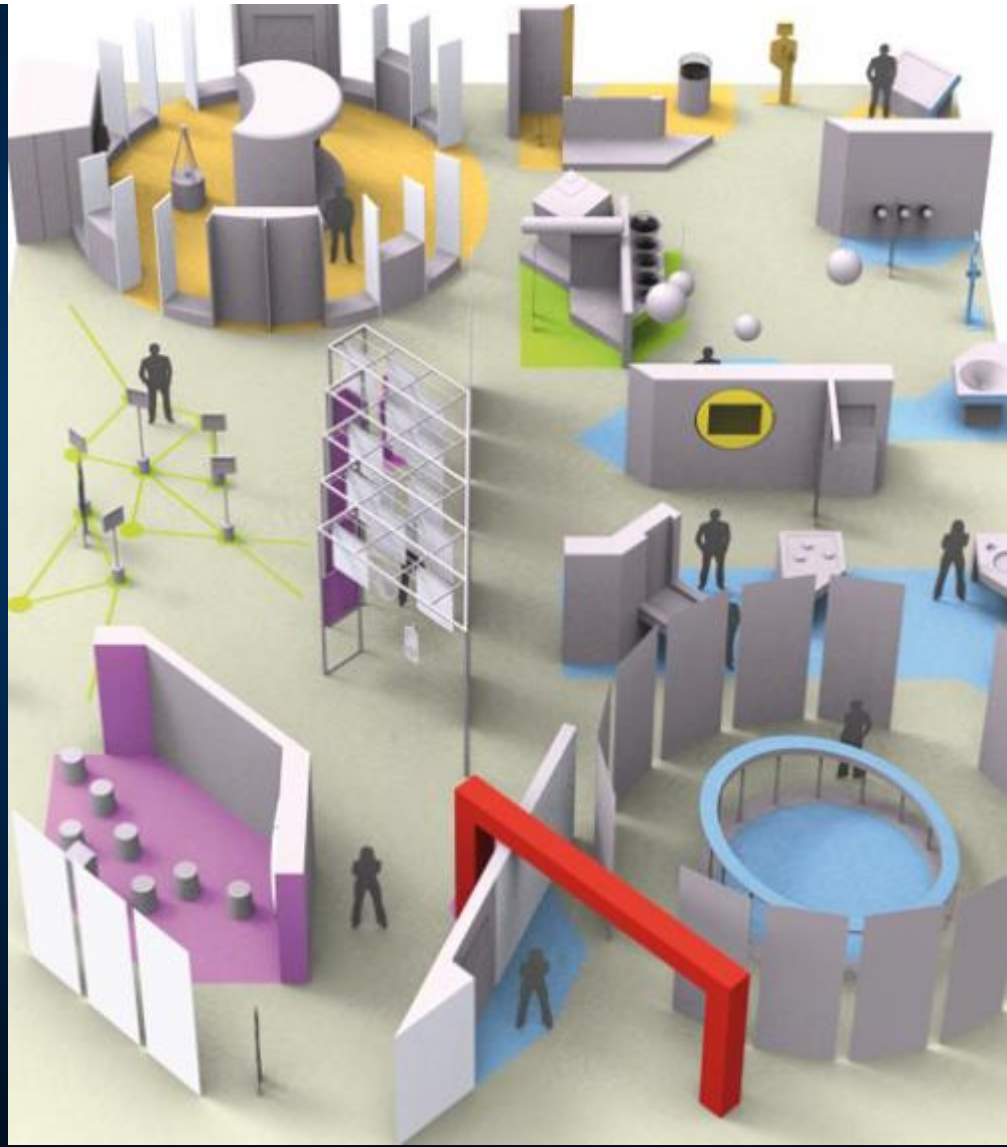
FROM **CERN** TO NEAR EAST AND NORTH AFRICA

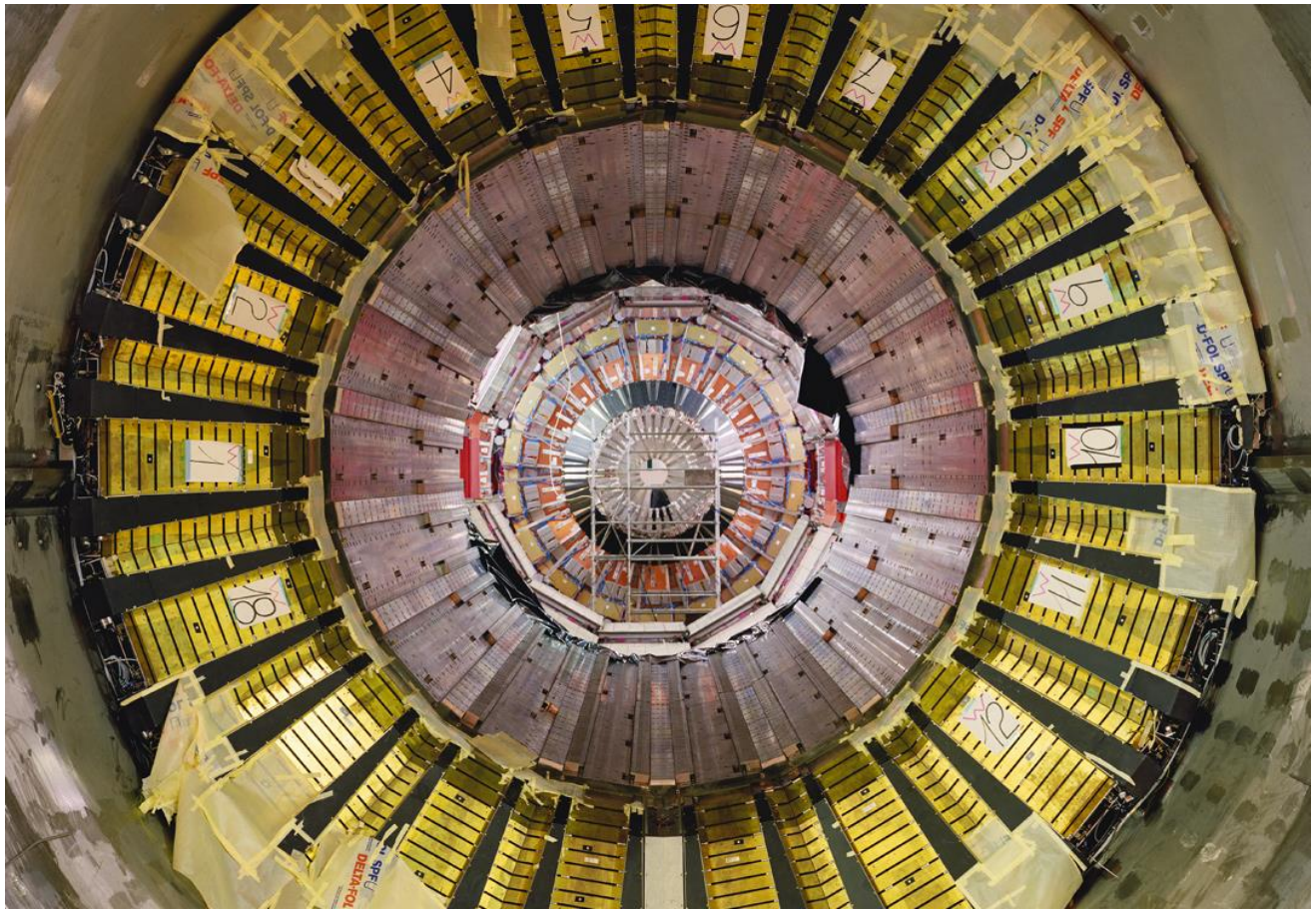
15 March 2012

ADDENDUM 1: LIST OF EXHIBITS

- The Universe as we understand it
- Open questions
- Answering machines/detectors (LHC)
- Beyond Physics (web, Spin-offs,..)

So far: Library Alexandria
"Alphabet of the Universe"





Knowledge is limited. Whereas the Imagination embraces the entire world… Albert Einstein

Bridge the gap between science and society …

CERN

– innovate, discover, publish, share

… and bring the world together