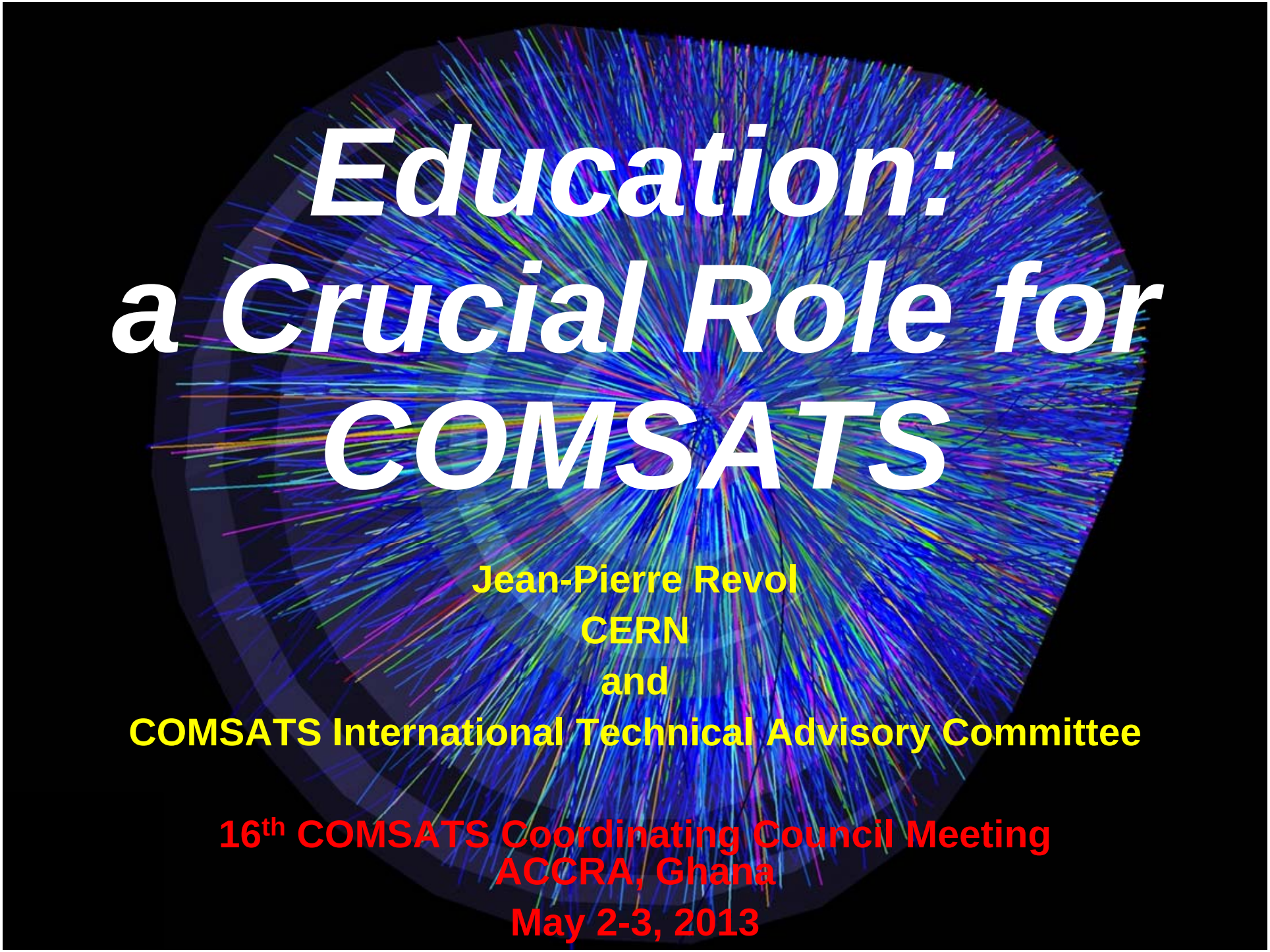


Education: a Crucial Role for COMSATS

Jean-Pierre Revol

CERN

and

COMSATS International Technical Advisory Committee

16th COMSATS Coordinating Council Meeting

ACCRA, Ghana

May 2-3, 2013

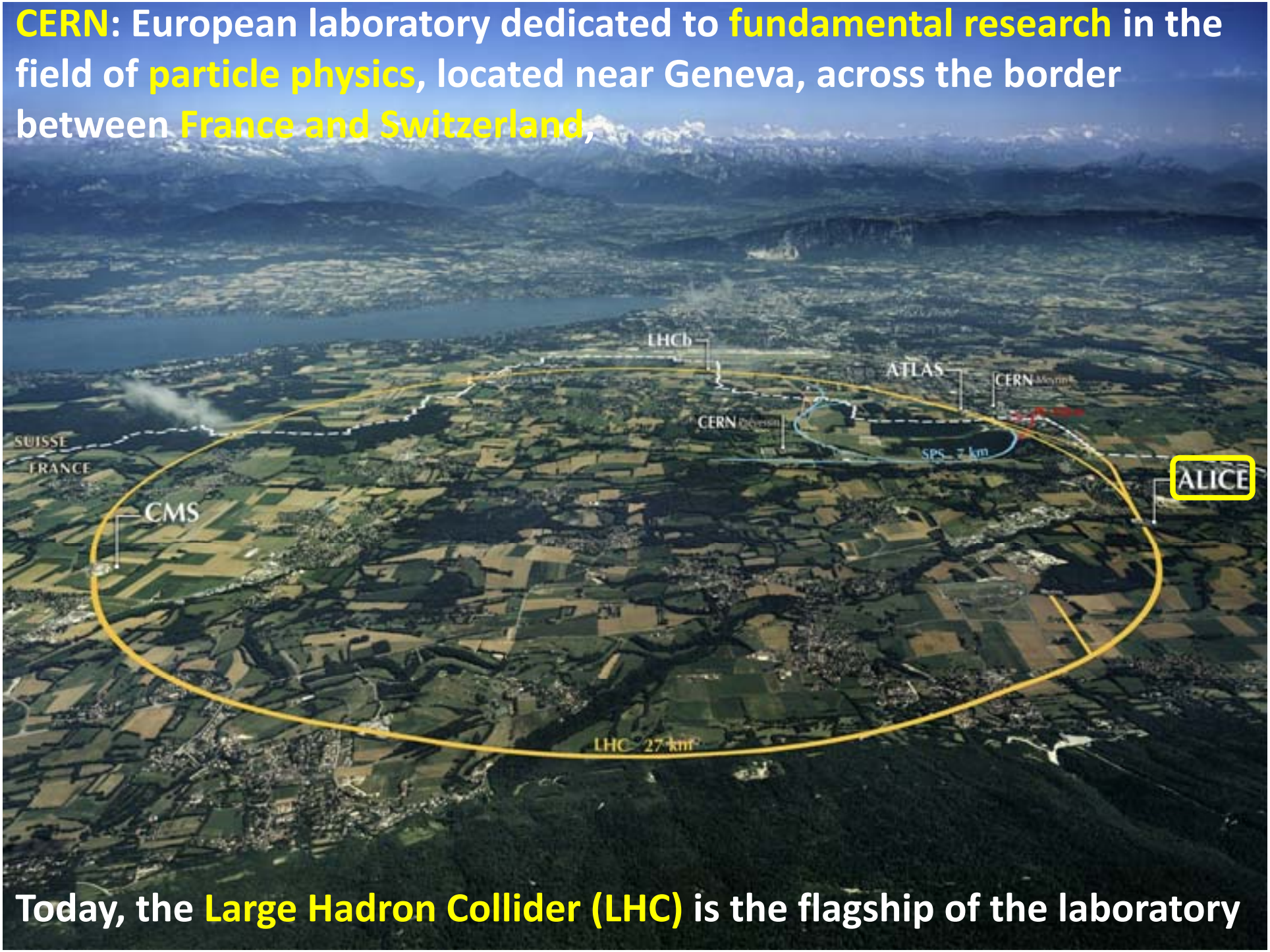
Introduction

- Many **thanks** to:
  - Dr. Abdulai Baba Salifu, Director General of the Council for Scientific and Industrial Research (CSIR), for inviting me to Ghana, his hospitality, and for teaching me "akwaaba"
  - Dr. Imtinan Elahi Qureshi, Executive Director of COMSATS, for inviting me to the 16th COMSATS Coordinating Council meeting, and for giving me a challenging mandate:

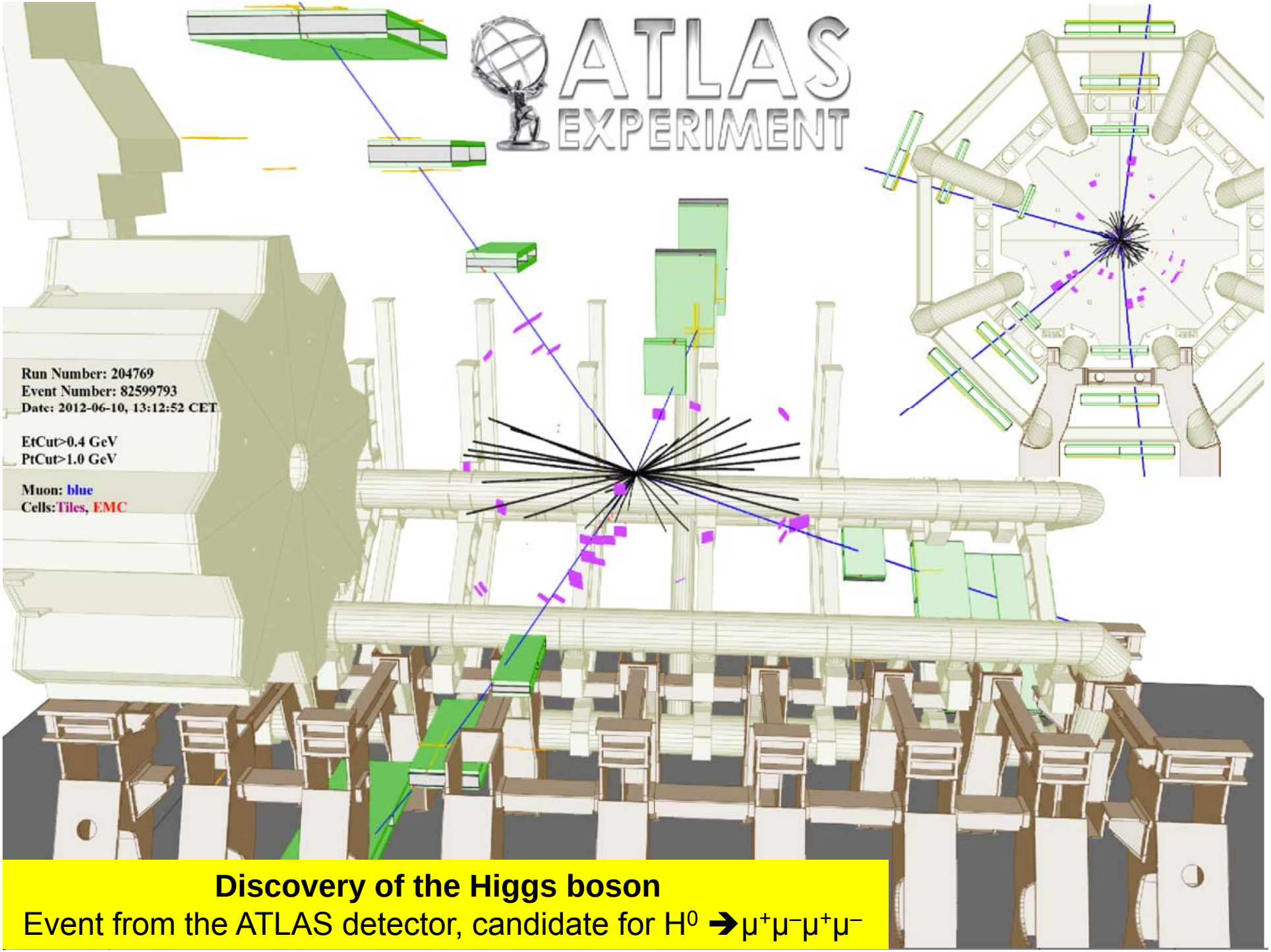
    "**What do I think COMSATS, as an international organization, should focus on in the future?**"

- A rather delicate subject for someone who is new to COMSATS International Technical Advisory Committee!
- I will draw from my experience as a scientist at CERN, as a former advisor to the Director General of CERN, and as a former coordinator of relations between CERN and a number of Non-Member State countries

CERN: European laboratory dedicated to **fundamental research** in the field of **particle physics**, located near Geneva, across the border between **France and Switzerland**,

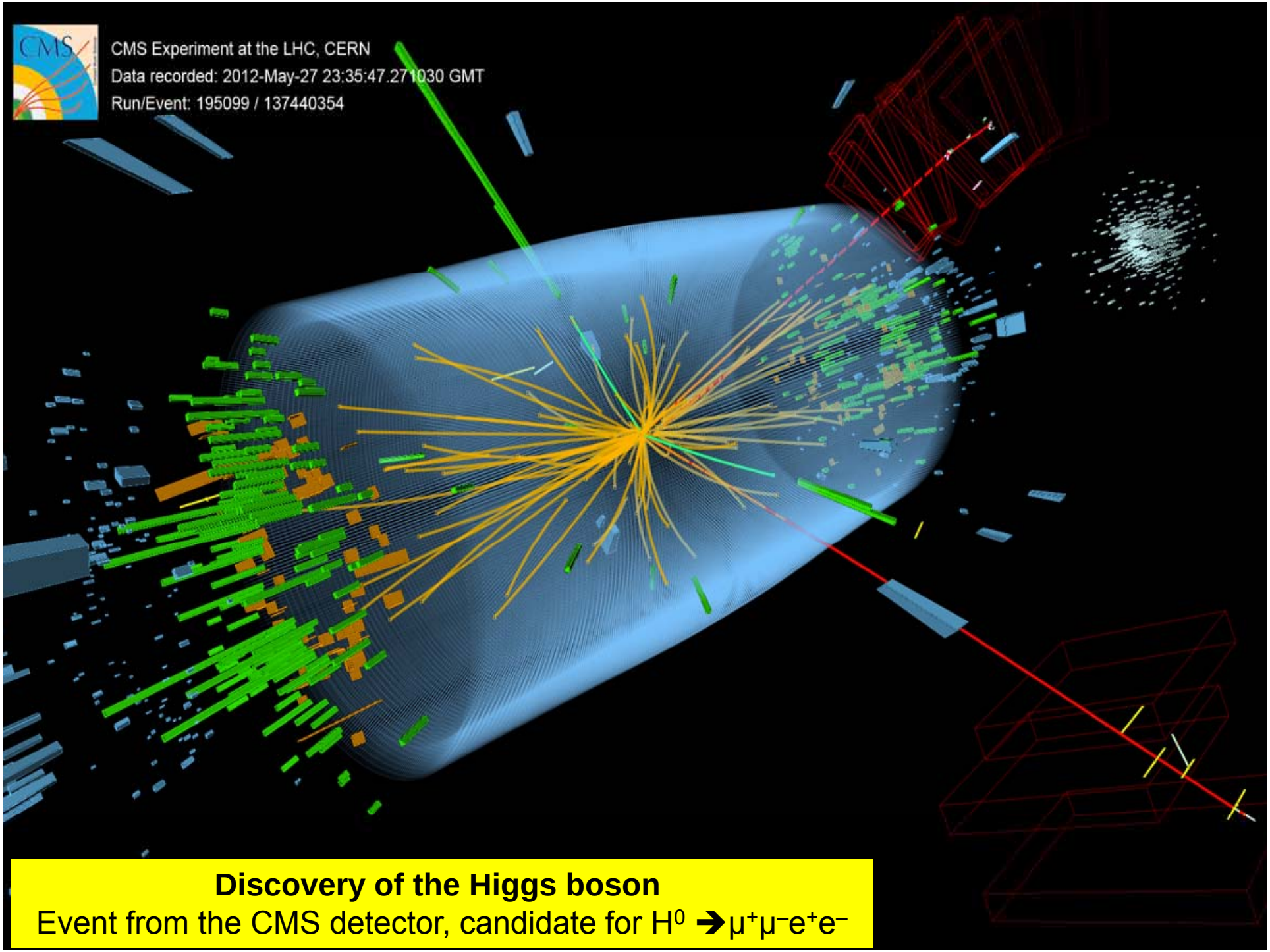


Today, the **Large Hadron Collider (LHC)** is the flagship of the laboratory



Discovery of the Higgs boson

Event from the ATLAS detector, candidate for $H^0 \rightarrow \mu^+\mu^-\mu^+\mu^-$



Discovery of the Higgs boson

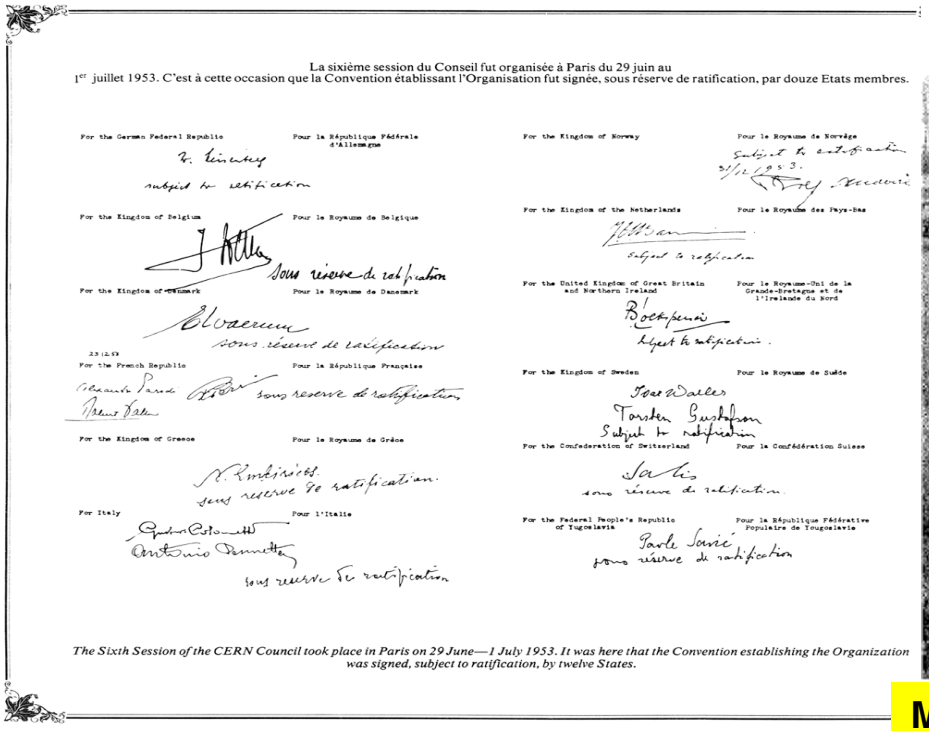
Event from the CMS detector, candidate for $H^0 \rightarrow \mu^+\mu^-e^+e^-$

Discovery of the Higgs boson

- A special particle, imagined in the 1960's to **answer the delicate question of mass** in the Standard Model of particles and interactions
- 50 years later, we found out that this mathematical construction of the human mind actually corresponds to the choice of Nature and is the answer to a question asked by humankind, in line with the many questions, which drove our evolution on Earth
- A major achievement for CERN, **for the scientists from all over the world involved in the CERN programme**, in a unique cooperation among countries
- This unique world-wide cooperation may in fact the biggest achievement of CERN, and could be an inspiration for other types of cooperation

CERN: European Organization for Nuclear research

- **1952**: the **C**onseil **E**uropéen pour la **R**echerche **N**ucléaire (**CERN**) **created with "a mandate to establish a world class European research organization in fundamental physics"**
- **1953**: a convention is signed establishing the Organization
- **1954**: birth of the laboratory – **12 European countries** (rebuilding Europe after World War II)



La sixième session du Conseil fut organisée à Paris du 29 juin au 1er juillet 1953. C'est à cette occasion que la Convention établissant l'Organisation fut signée, sous réserve de ratification, par douze Etats membres.

For the German Federal Republic — Pour la République Fédérale d'Allemagne
subject to ratification

For the Kingdom of Belgium — Pour le Royaume de Belgique
sous réserve de ratification

For the Kingdom of Denmark — Pour le Royaume de Danemark
sous réserve de ratification

For the French Republic — Pour la République Française
sous réserve de ratification

For the Kingdom of Greece — Pour le Royaume de Grèce
sous réserve de ratification.

For Italy — Pour l'Italie
sous réserve de ratification

For the Kingdom of Norway — Pour le Royaume de Norvège
Subject to ratification

For the Kingdom of the Netherlands — Pour le Royaume des Pays-Bas
subject to ratification

For the United Kingdom of Great Britain and Northern Ireland — Pour le Royaume-Uni de la Grande-Bretagne et de l'Irlande du Nord
Subject to ratification.

For the Kingdom of Sweden — Pour le Royaume de Suède
Subject to ratification

For the Confederation of Switzerland — Pour la Confédération Suisse
sous réserve de ratification.

For the Federal People's Republic of Yugoslavia — Pour la République Fédérative Populaire de Yougoslavie
sous réserve de ratification

The Sixth Session of the CERN Council took place in Paris on 29 June—1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by twelve States.

May 17 1954, construction starts at Meyrin, near Geneva

CERN today: 20 Member States

~ 2300 staff; ~ 980 other paid personnel
> 10000 users
Budget (2012) ~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

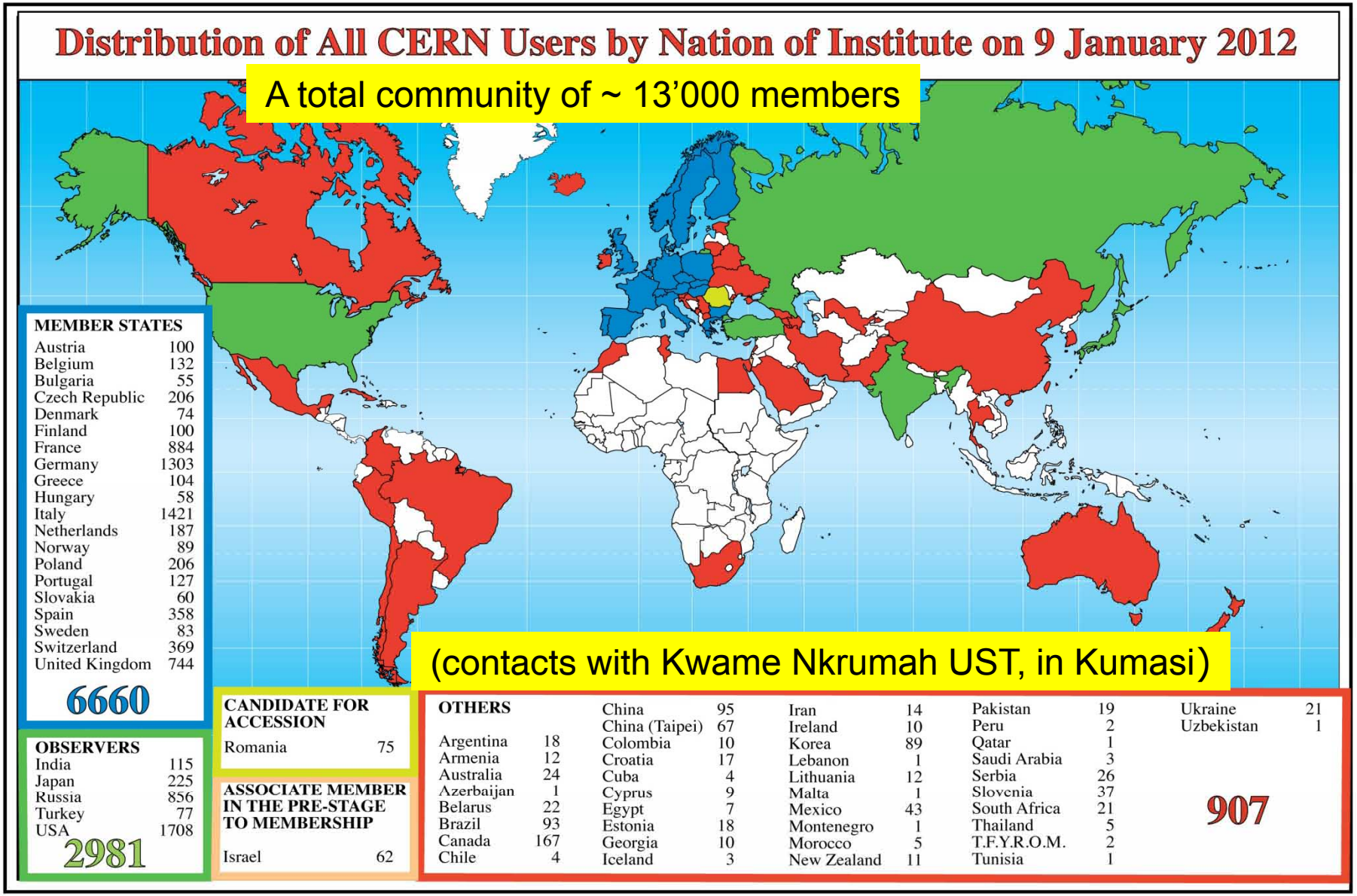
Observers to Council: India, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO

CERN is an observer to the United Nations General Assembly

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

Applicant States: Cyprus, Slovenia, Turkey, (Pakistan, Brazil, Russia preparing)

From a European laboratory to a World laboratory



COMSATS and CERN

- The idea of a high-level Commission on Science and Technology for countries of the South was triggered by a **physicist, Nobel laureate from Pakistan: Prof. Abdus Salam**
- Both COMSATS and CERN are **promoting science and technology** as a means of strengthening South-South and North-South collaboration
- In doing so, both international organizations are **promoting education**, which is crucial to the harmonious development of human civilization

Education is one area where COMSATS could play a more important role

COMSATS and CERN

- COMSATS consists of **21 member countries** from Africa, Asia and America.

- CERN consists of **20 European countries** (soon 21 as Romania is in the process of becoming a member state) and cooperates with ≥ 45 countries from Africa, Asia, America, Australia and Europe.

- Six members of COMSATS are cooperating with CERN: People's Republic of **China**, Republic of **Colombia**, Arab Republic of **Egypt**, Islamic Republic of **Iran**, Islamic Republic of **Pakistan**, Republic of **Tunisia**.

Fundamental and innovation

- **Human curiosity** is at the basis of the evolution of Society. Human evolution is linked to the ability to ask questions. It is here in Africa that the very first questions were formulated.
- **Fundamental research** is the expression of **human curiosity** in three main domains:
  - **Structure of matter** (particle physics, nuclear physics, solid state physics, etc.)
  - **Life** (botany, chemistry, molecular biology, etc.)
  - **Structure of the Universe** (astronomy, astrophysics, cosmology, etc.).
- Finding answers to questions led to innovations and development, as still happens today:
  "I think there is hardly any example of twentieth century innovation which is not indebted in some way to basic scientific thought" **(Hendrik Casimir)**

Fundamental research and innovation

- History shows clearly that it is **fundamental research** that **drives the development and progress of Society:**
  - Without fundamental research there is no innovation
  - Without innovation there is no development

- Unfortunately, politicians seem to have difficulties understanding this. It is even more true in member-countries of COMSATS:
  "**COMSATS *member-countries devote, on average, about 0.5 per cent of their national budgets to science, compared to 2.5 per cent by developed countries***"

  Eduardo Posada Florez
  (Chair of COMSATS Coordinating Council)

How does fundamental research feed innovation?

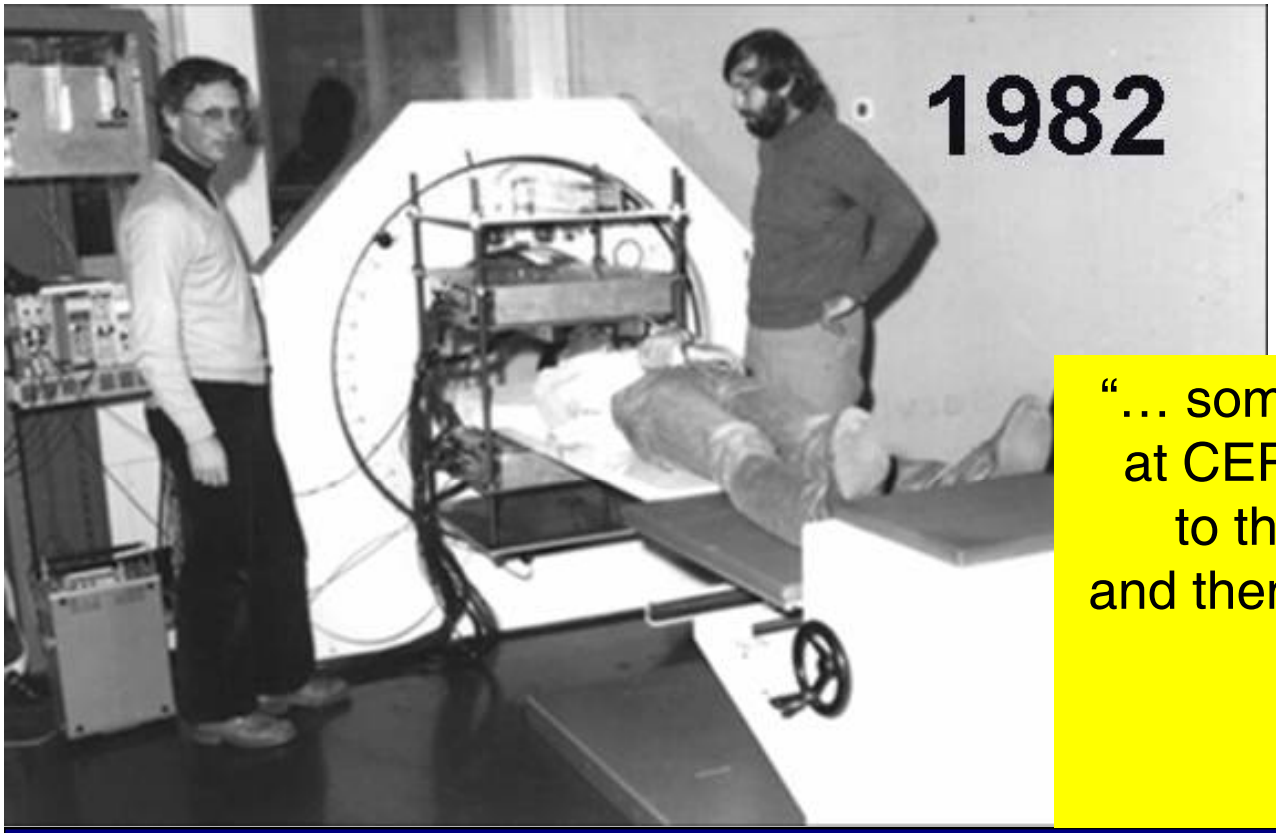
- **Direct ways:**
  - For instance **Faraday's work**
  - The **discovery of the spin of the proton** opened the way to medical imaging by **Nuclear Magnetic Resonance technique**
  - **Quantum Field Theory** led to using antimatter (e^+e^- tomography), etc.
- **Indirect ways: Tools** developed for fundamental research find applications in other areas:
  - Application of **accelerator & detector technology** to medicine
    - Hadron therapy (cyclotrons) [Centre Lacassagne, TERA, …]
    - Production of radioactive isotopes medicine & industry
    - Industrial processes using accelerators
  - Application of physics methods and instrumentation to biology (Maurice Wilkins – J.D. Watson & F. Crick 1962)
  - Accelerator driven power plants using thorium for energy production and destruction of nuclear waste

EDUCATION

CERN and PET/CT scanners

- First PET scanner developed in collaboration between CERN and Geneva Cantonal Hospital. (David W. Townsend, Alan Jeavons and Prof. Alfred Donath)

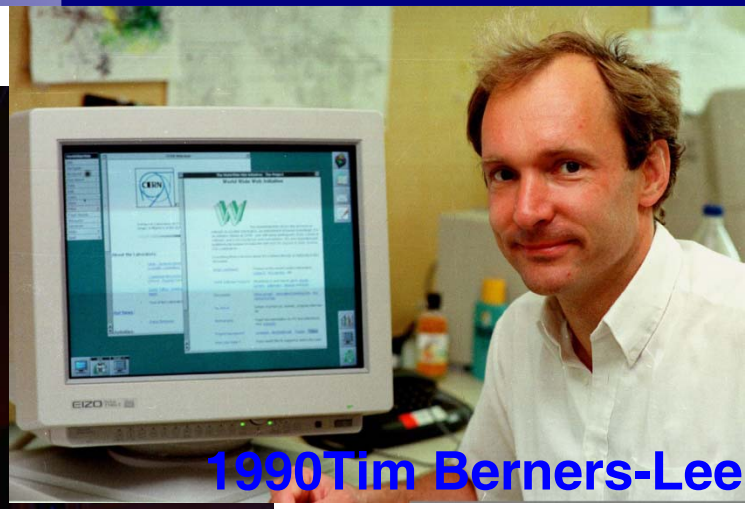
W.C. Röntgen, 22 Nov. 1895



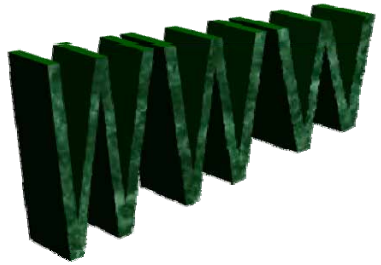
"… some essential and early work at CERN contributed significantly to the development of 3D PET, and then to a new scanner design, the Advanced Rotating Tomograph."

David Townsend, 2008

CERN and the WWW

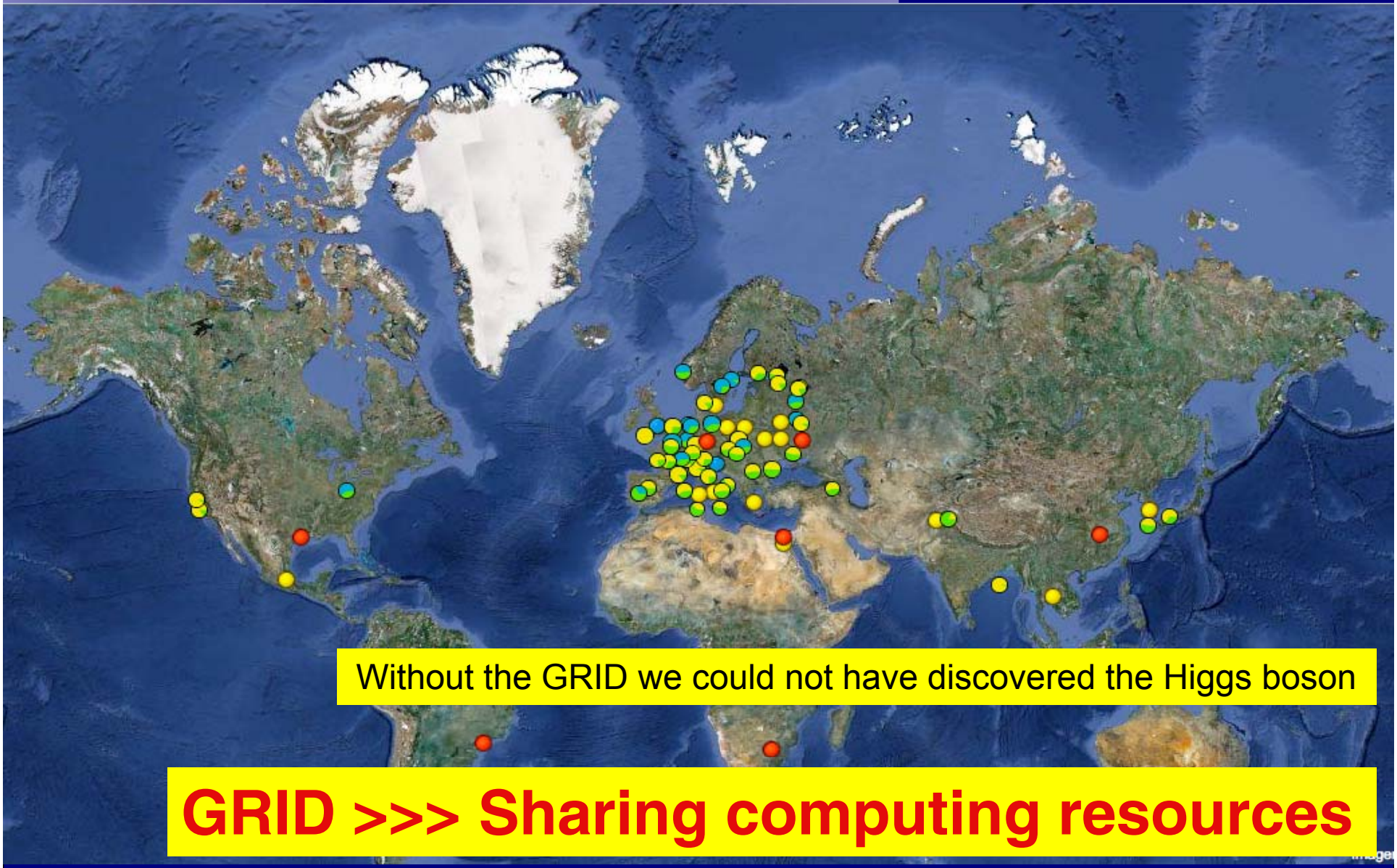


“WWW … changed forever the way information is shared”



WWW >>> Sharing information

CERN and the WLCG (World LHC Computing Grid)

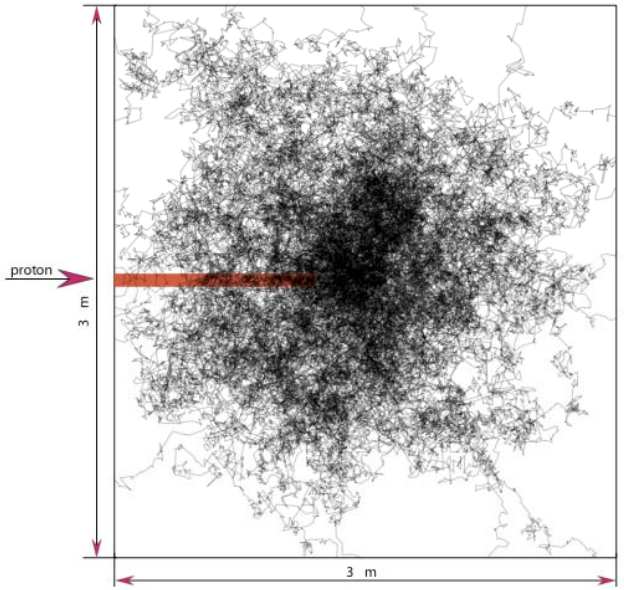


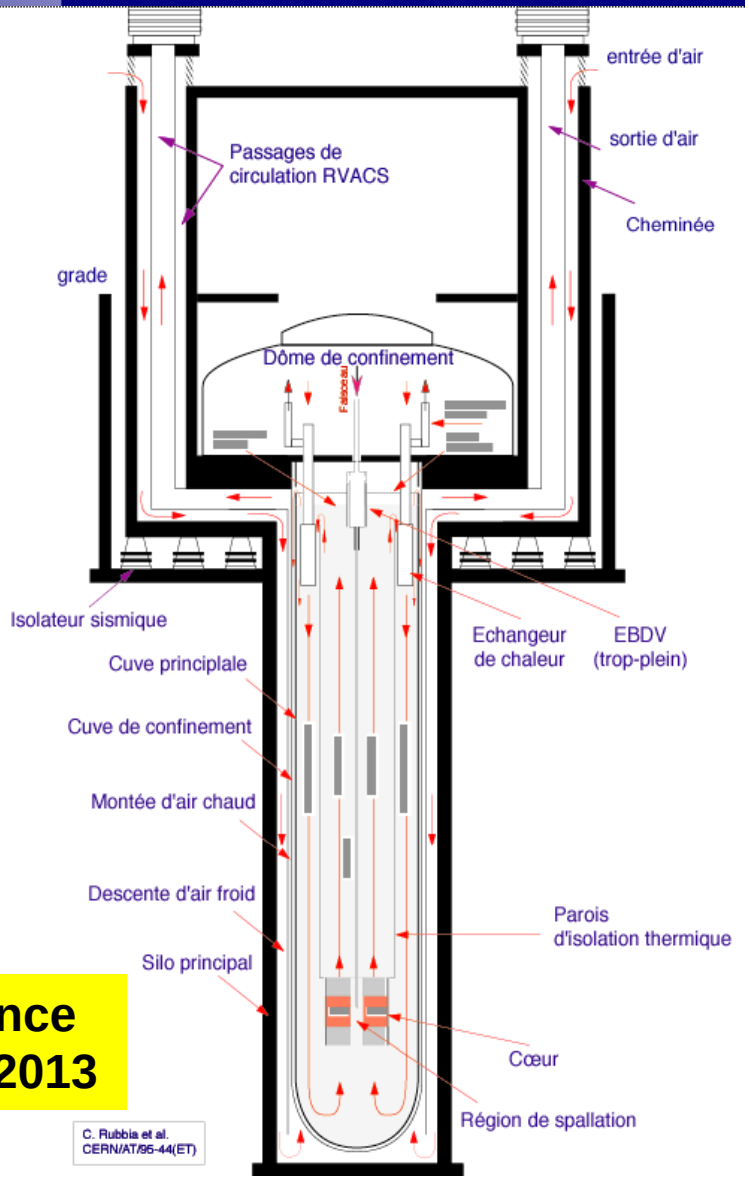
Without the GRID we could not have discovered the Higgs boson

GRID >>> Sharing computing resources

CERN and thorium energy

- ***The Energy Amplifier***, an accelerator-driven system proposed by Nobel laureate Carlo Rubbia
- Concept validated by CERN **FEAT and TARC** experiments, which led to other applications:
  - Isotope production for medical diagnostics (**CERN Patent**)
  - Neutron facility **n_TOF**]





ThEC13 Conference
CERN Oct. 27-31, 2013

Education

- How could there be research and development without education?
- Education is the most judicious investment a society can make:
  - a **benefit to society**, as educated people understand society better and may contribute to its development
  - a **benefit to individuals**, as education helps them understand better their place in society and allow them to contribute to its development
- Research needs educated people, this is one of the reasons why Europe is investing in CERN
- In return, CERN plays an important educational role, as most CERN staff go to industry after a few years of research at CERN and bring with them their experience from CERN

Educational programmes at CERN

How does it work?

- Raise the interest of young people by introducing them to modern science topics they find interesting and challenging (similar approach by Prof. Adewale Solarin in Nigeria)
- Once they are interested, students are motivated, willing to learn basic concepts, and they start asking questions:
  - At this stage, we are back to the basic mechanisms of evolution and innovation
- **Importance of training physics teachers:**
  - Teachers are role models
  - There is a multiplication factor
  - Teachers constitute a unique link in bringing modern science to the classroom

CERN ‘themes’ are attractive for young people:

ANTIMATTER

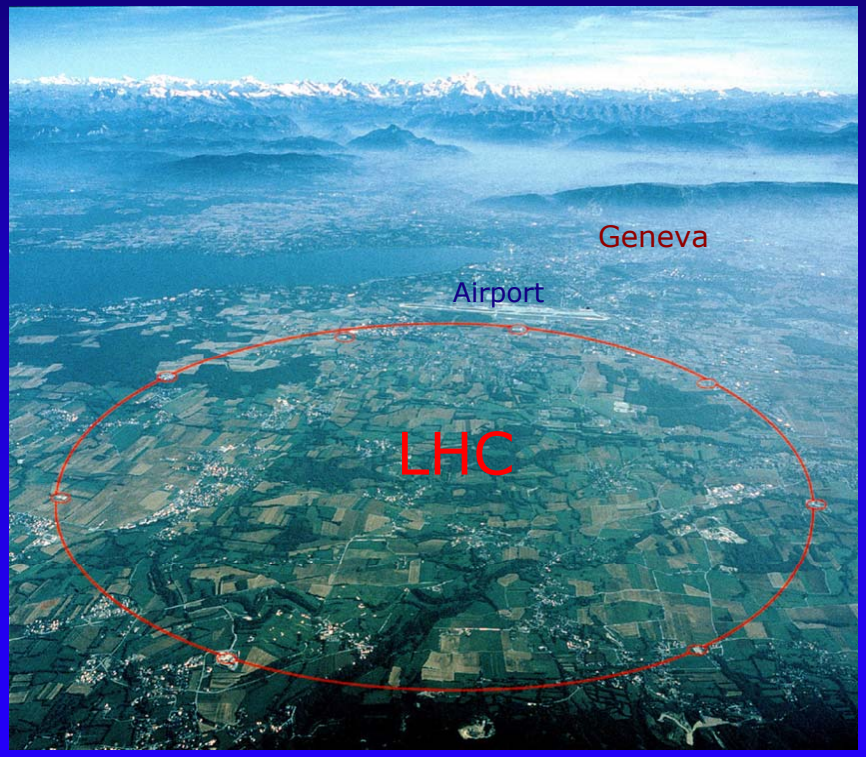
BLACK HOLES

DARK MATTER

THEORY OF EVERYTHING

WWW

PET SCAN



THE Higgs PARTICLE

DARK ENERGY

BIG BANG

EXTRA DIMENSIONS

GRID

HADRONTHERAPY

An educational role for COMSATS?

- Education was clearly on the mind of **Abdus Salam**, when COMSATS was created, thus I think that **COMSATS, as an international organization, should focus on education in the future**
- This is the best way to have countries from the South help themselves – this educational effort should target children, students, teachers and perhaps also politicians …?
- This could be done initially through cooperation with CERN, and perhaps other international organizations (UNESCO?)
- COMSATS could start by taking and expanding some of the most successful CERN programmes (Physics teachers programmes, Physics schools, etc.)
  Potentially interesting multiplication factor for COMSATS (X 21 countries)

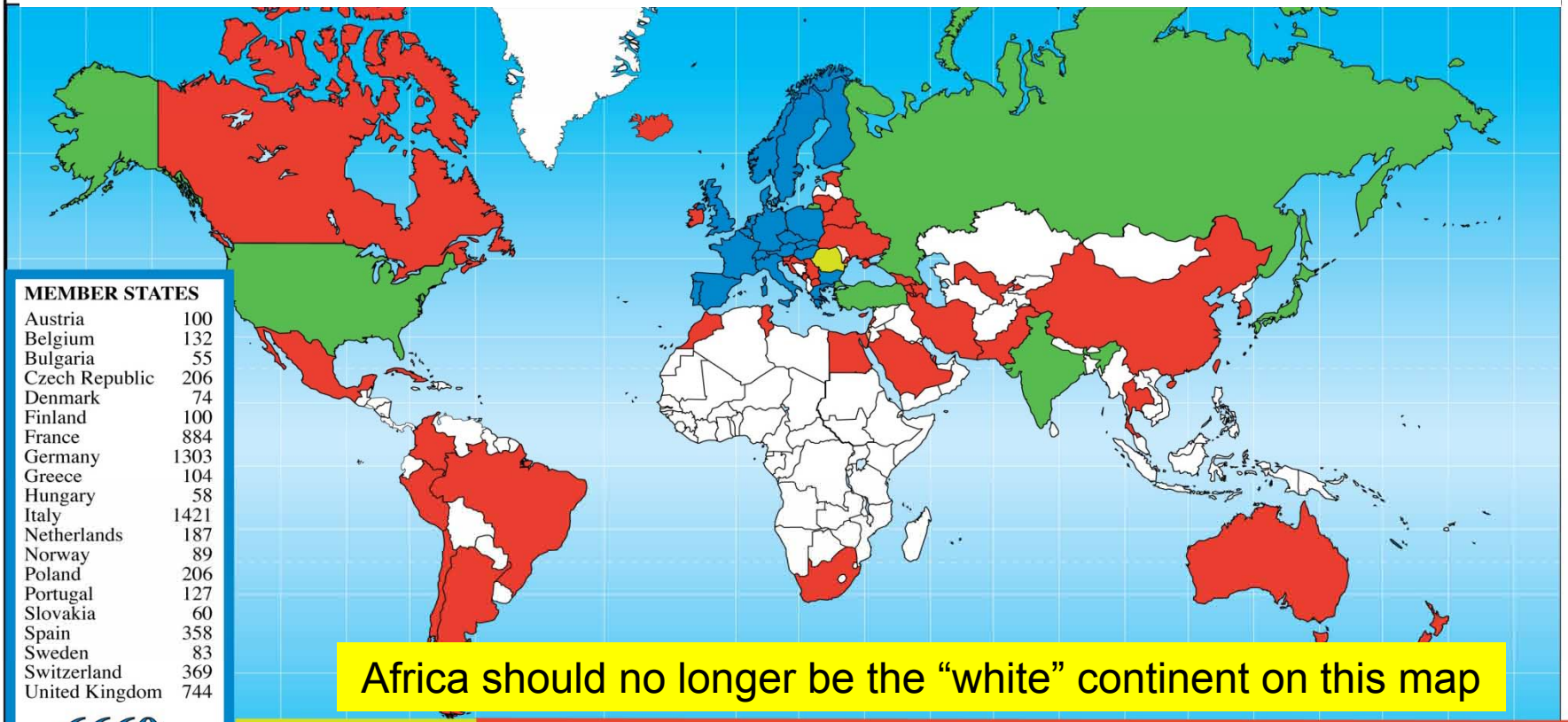
A possible practical scheme

- Start by running, with the help of CERN, the teachers programme, in any of the COMSATS countries
- Train COMSATS personnel who could run the programme within the country, and who could export it to other COMSATS member countries
- This only requires modest resources. Follow the advice of Sherry Ayittey, Ghana's former minister for environment, science and technology, concerning fund raising

Is there any good reason not to try to do it?

World-wide scientific cooperation

Build on the universal character of Science



Africa should no longer be the “white” continent on this map

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

Argentina	18	China	95	Iran	14	Pakistan	19	Ukraine	21
Armenia	12	China (Taipei)	67	Ireland	10	Peru	2	Uzbekistan	1
Australia	24	Colombia	10	Korea	89	Qatar	1		
Azerbaijan	1	Croatia	17	Lebanon	1	Saudi Arabia	3		
Belarus	22	Cuba	4	Lithuania	12	Serbia	26		
Brazil	93	Cyprus	9	Malta	1	Slovenia	37		
Canada	167	Egypt	7	Mexico	43	South Africa	21		
Chile	4	Estonia	18	Montenegro	1	Thailand	5		
		Georgia	10	Morocco	5	T.F.Y.R.O.M.	2		
		Iceland	3	New Zealand	11	Tunisia	1		

907

CONCLUSION

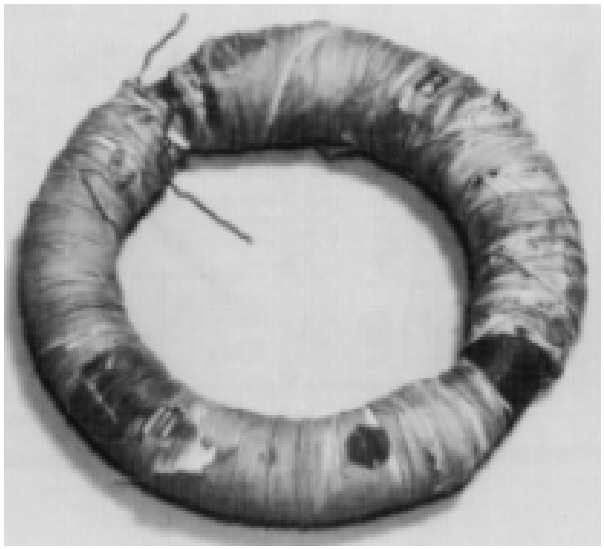
- **Science**:
  "*Coherent ensemble of **knowledge** concerning certain categories of facts, objects or phenomena obeying laws and verified by experimental methods*"
  (Larousse Dictionary)
- **Knowledge** is the most precious asset of humankind
- Science must be a bigger part of our culture
- Developing science through education, research and development must be a priority of Society
- **COMSATS can play a crucial role** in the development in the South, **focusing on education** – well in line with COMSATS' mandate

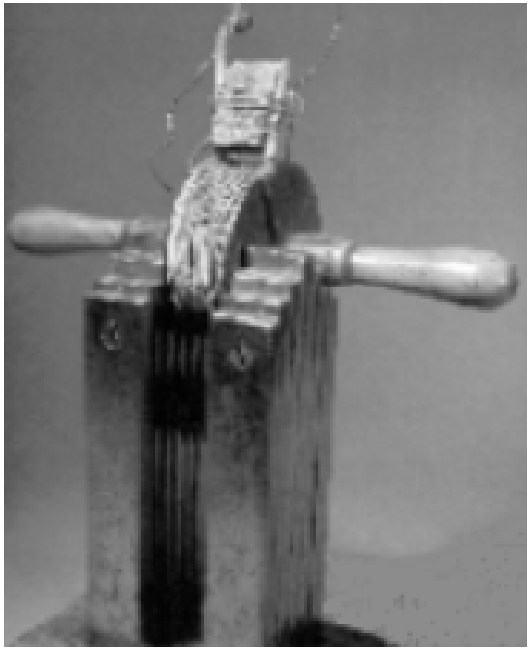
Contents

- Introduction
- CERN and COMSATS
- The Role of Science in Society
- CERN's Educational role
- An education role for COMSATS

Michael Faraday

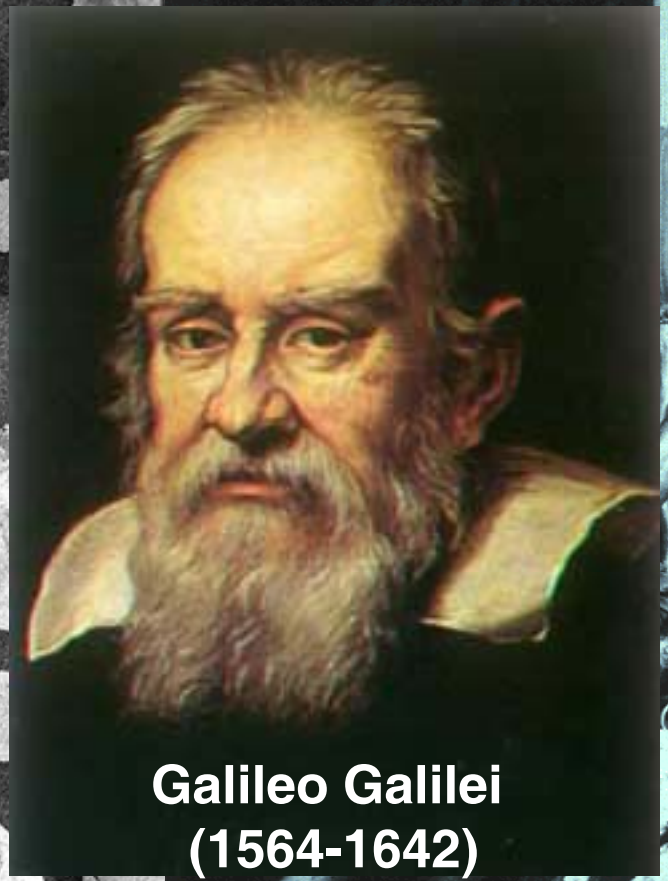
- Faraday, famous 19th century English physicist (1791-1867) contributed brilliantly both to applied research and to fundamental research.





- Why do we remember Faraday today? Not because he improved light house candles!

A the time of Galileo, **Observation** became the basis for advancing science, and **instruments** could be built to allow observations beyond the natural possibilities of human beings

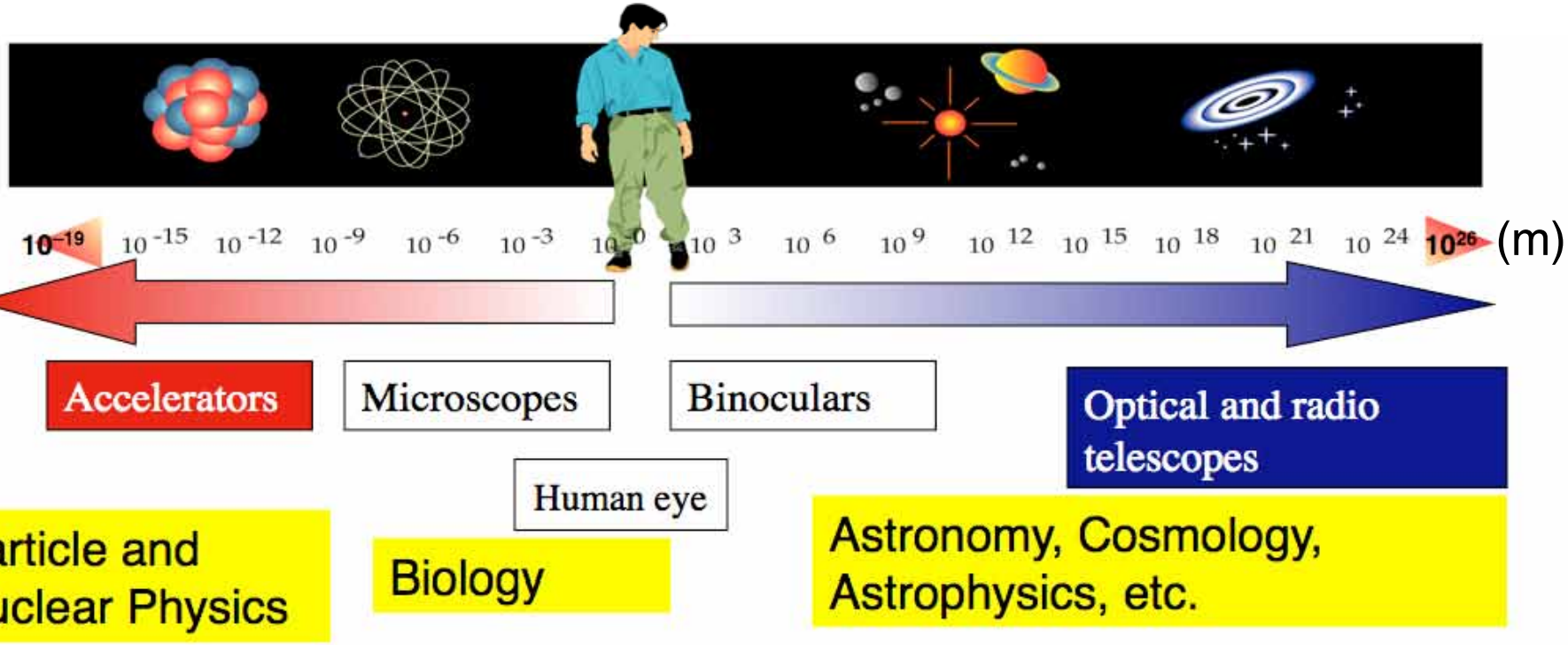


Galileo Galilei
(1564-1642)

J. Lipperhey **1608**
Gallileo 1609

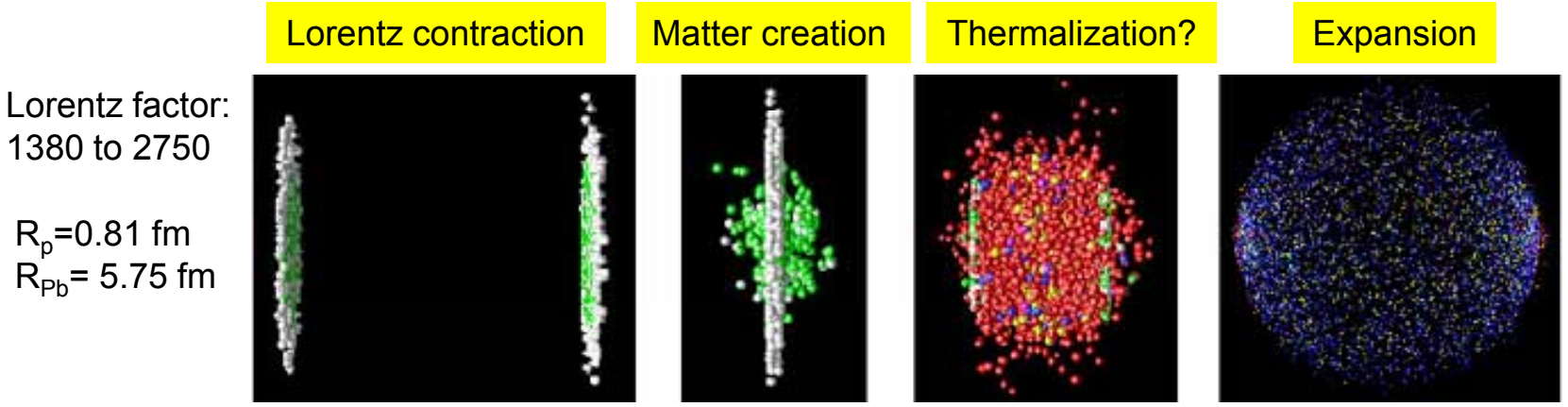
Tremendous domain of physics!

- Today, scientists are studying the Universe over dimensions varying by 45 orders of magnitude!



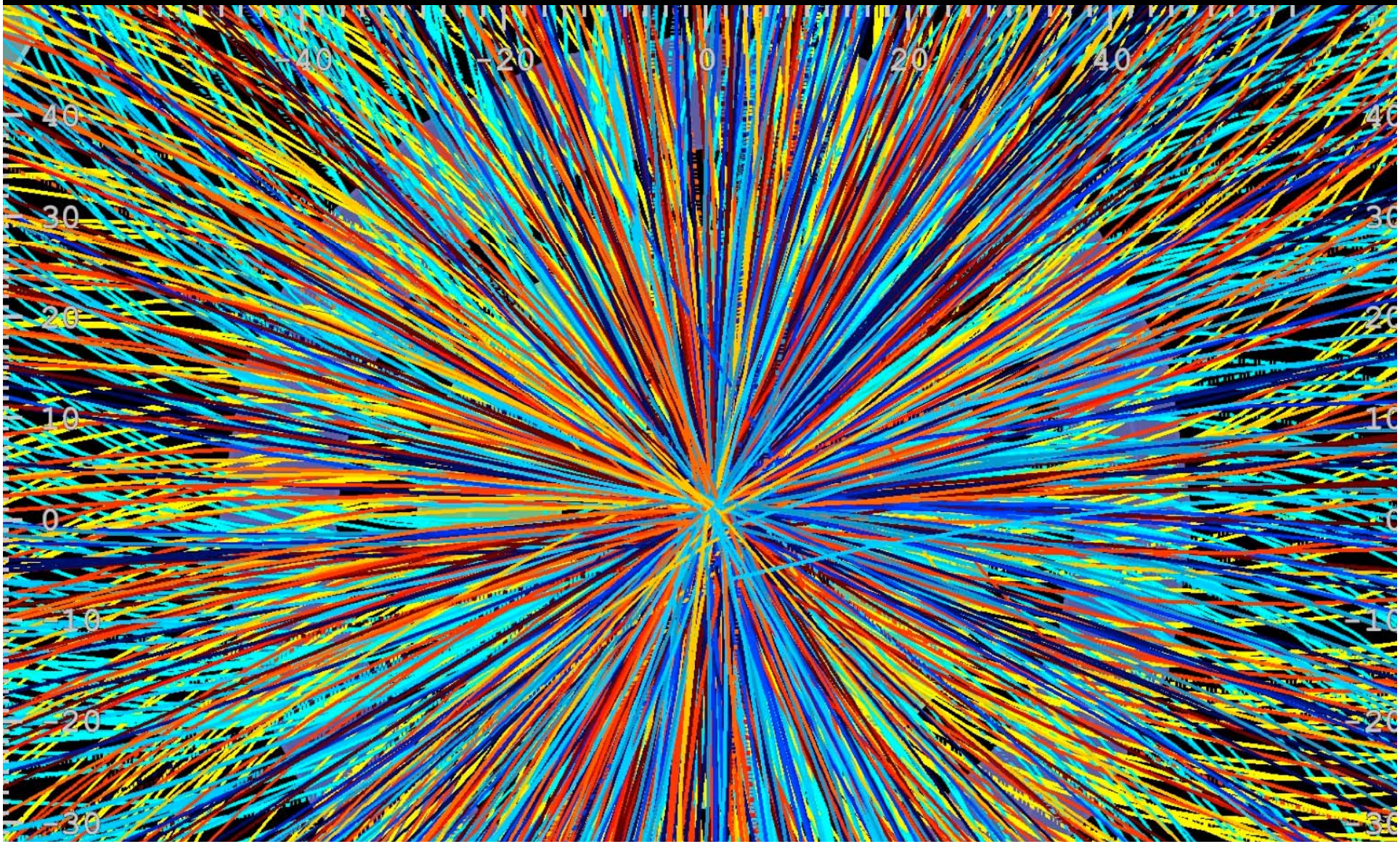
- As instruments become more powerful, we are expanding the scale and studying new features

Challenges of heavy ion physics

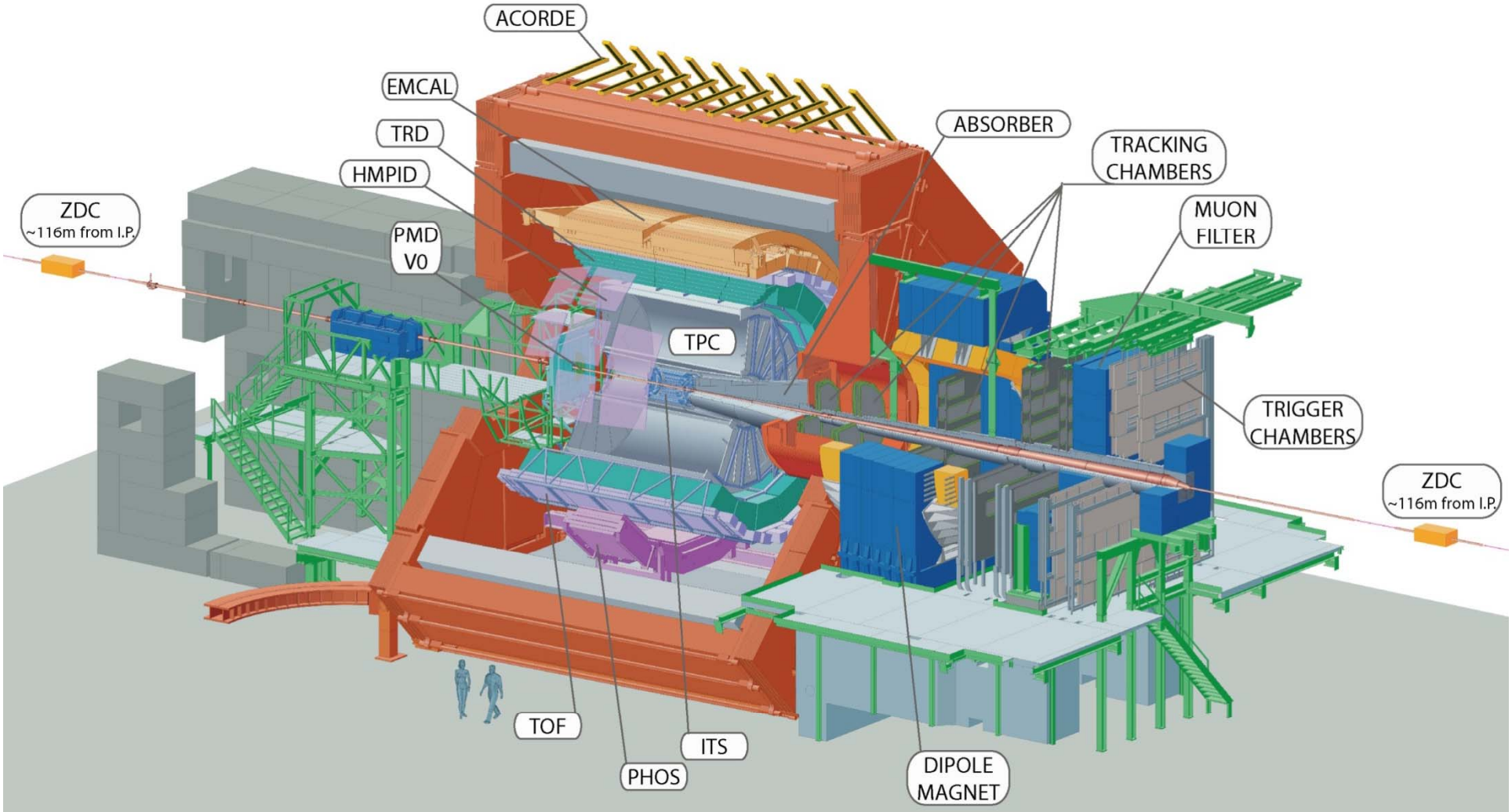


- **Theoretical challenge**: Involves **many concepts** from elementary particle physics, nuclear physics, equilibrium and non-equilibrium thermodynamics and hydrodynamics
- **Experimental challenge**: **fast** ($\approx 10^{-23}$s) dynamical evolution, from **extreme initial conditions** to a dilute hadronic final state**; extreme experimental conditions**:
  - **extreme particle density** ($dN_{ch}/d\eta \approx 2000$)
    - **x 500** compared to pp@LHC
  - **requires large dynamic range** in p_T:
    - from very soft (**0.1 GeV/c**) to fairly hard (**100 GeV/c**)
  - **requires particle identification (PID for hadrons and lepton)**, **which limits** luminosity and interaction **rates**
    - **10 kHz** (Pb-Pb), **200 kHz** (pPb), **300 kHz** (pp) (< 1/1000 of pp@10^{34} cm^{-1} s^{-2})

PbPb collision in the ALICE detector



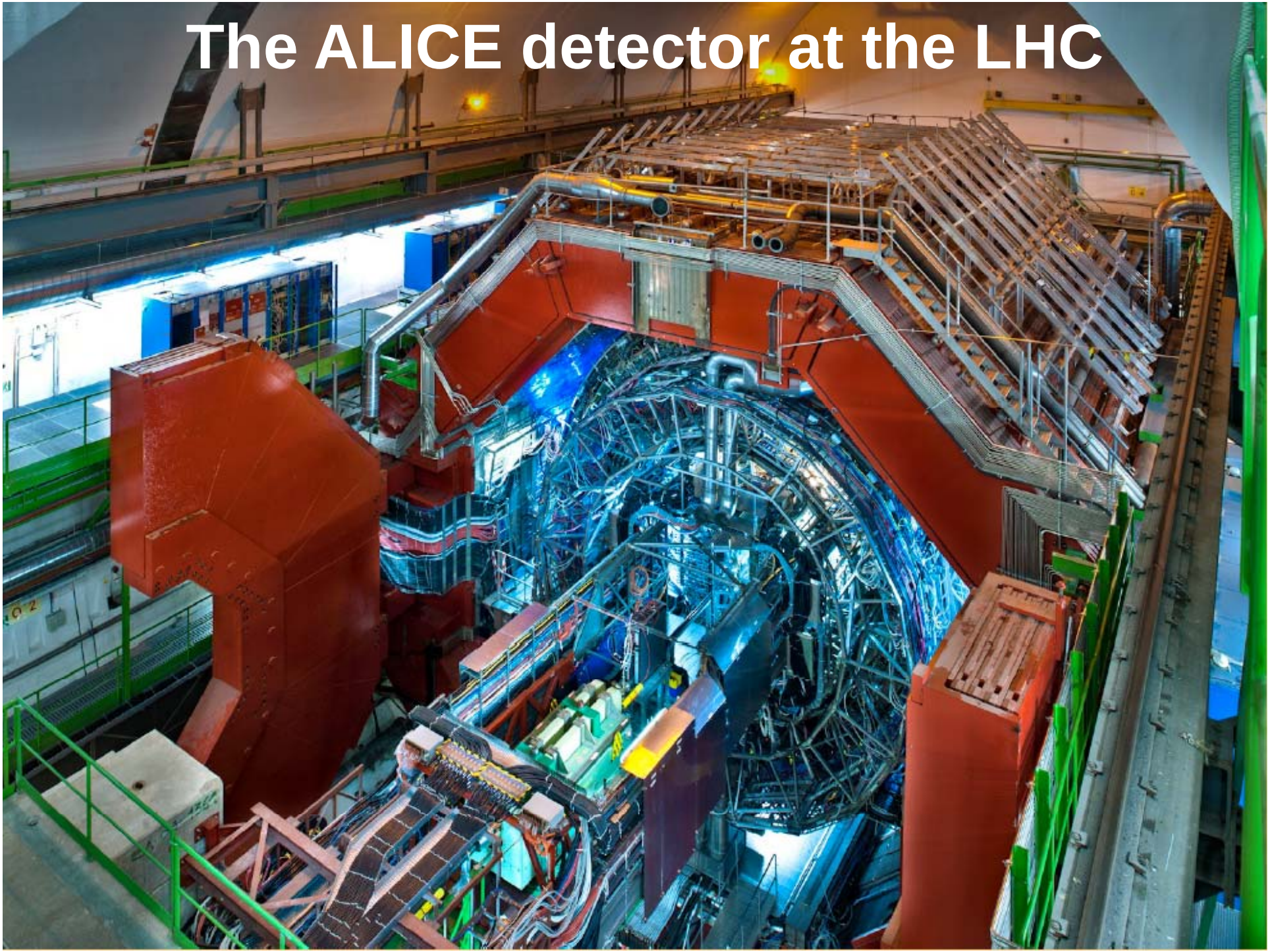
The ALICE detector at the LHC



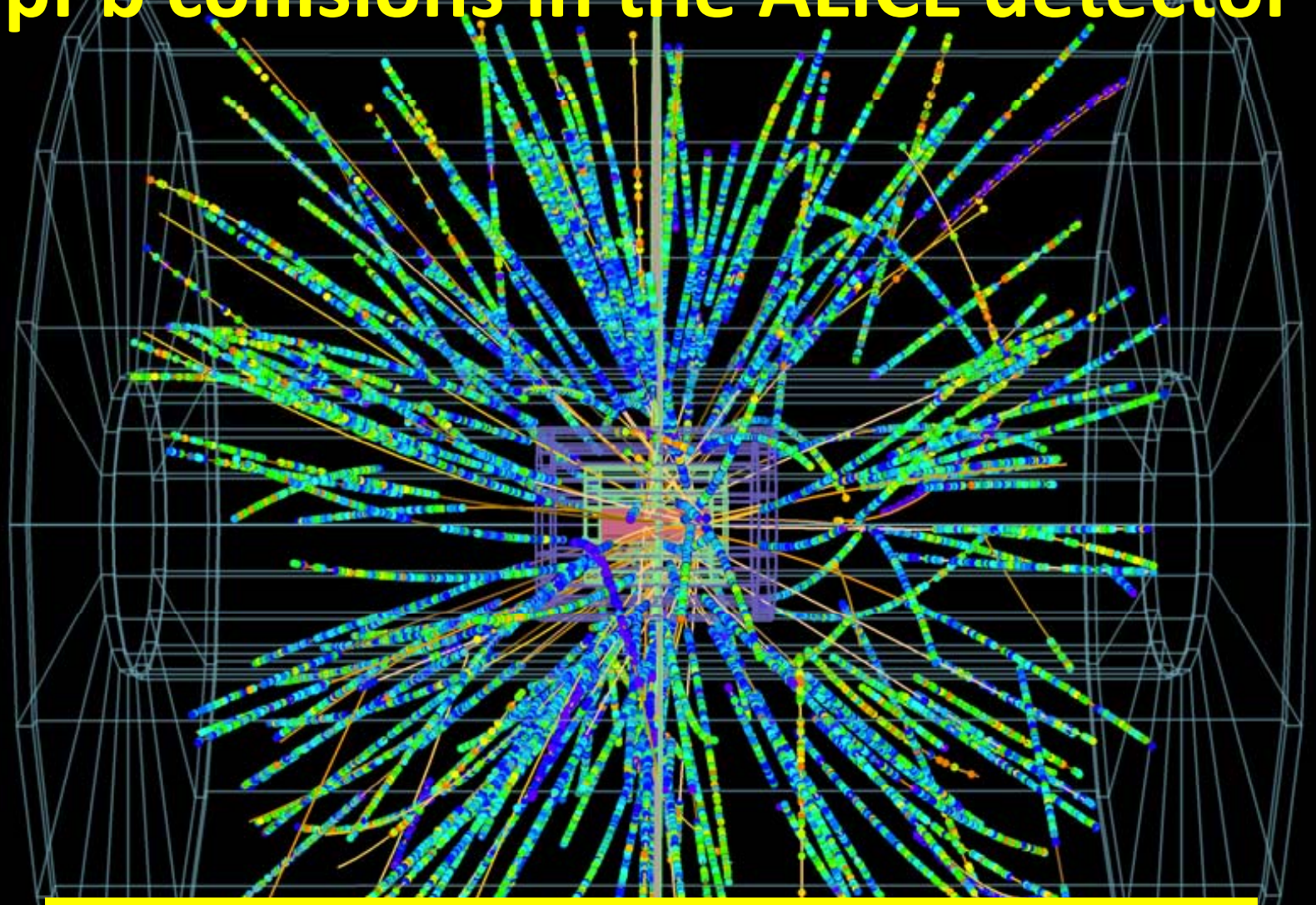
Detector:
Length: 26 meters
Height: 16 meters
Weight: 10,000 tons

Collaboration:
> 1000 Members
> 100 Institutes
> 30 countries

The ALICE detector at the LHC



pPb collisions in the ALICE detector

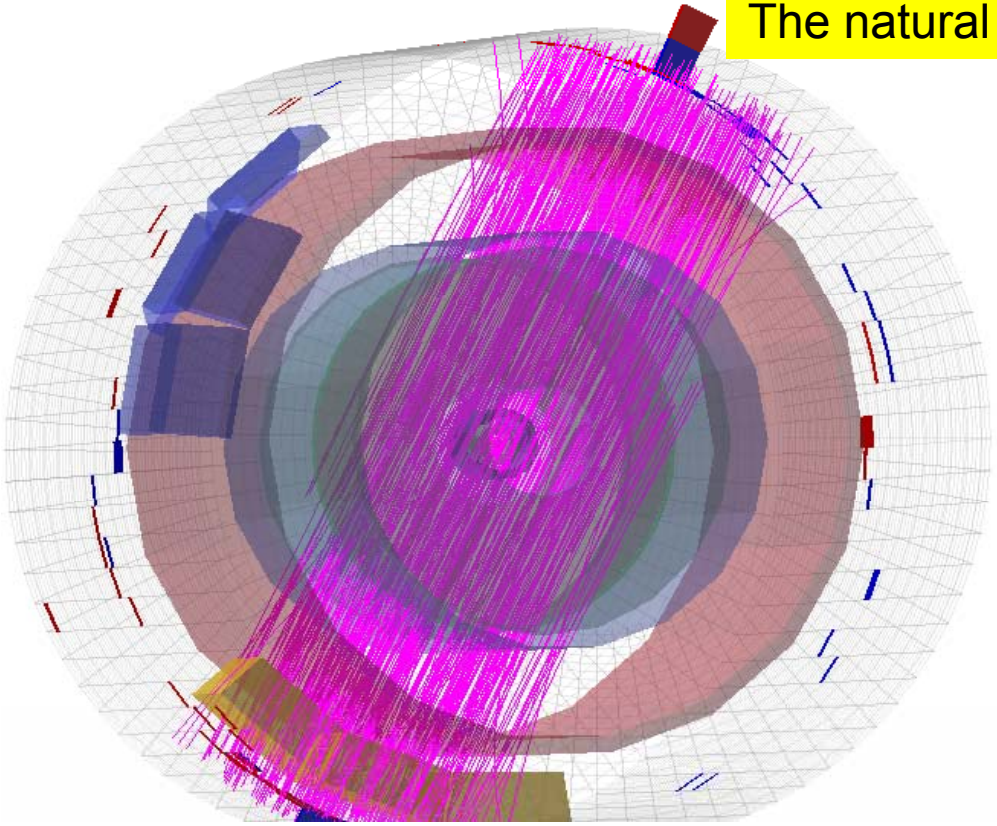


– Low luminosity (8×10^{25} cm^{-2} s^{-1}) pilot run in September 2012
– 30 nb^{-1} collected by ALICE in a run started mid-January 2013, which ended February 10, 2013
– At $\sqrt{s}$ = 5.02 TeV, the c.m. reference frame moved by $\Delta\eta$ = 0.465

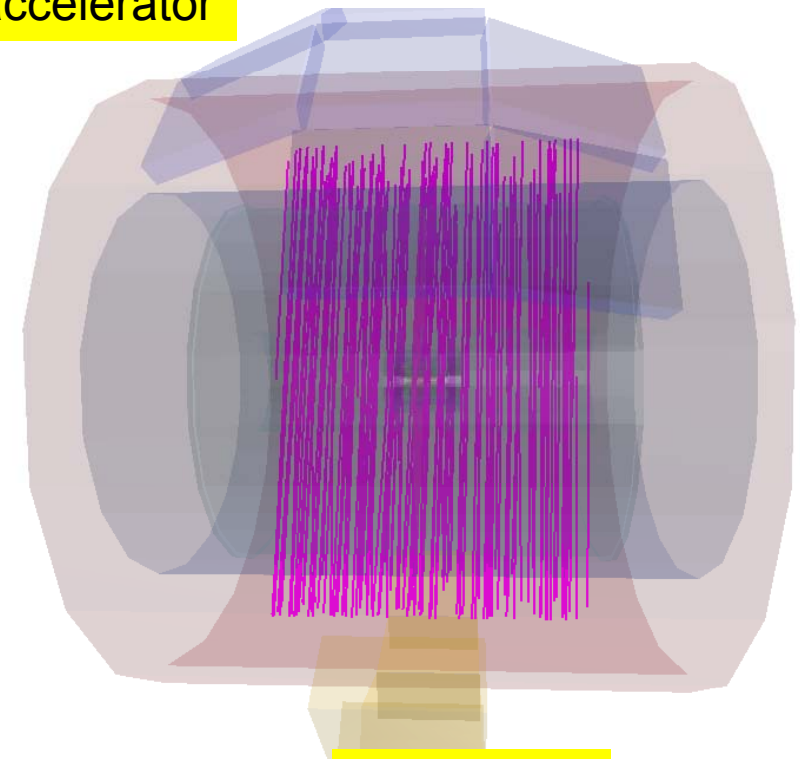
Cosmic ray shower in the ALICE detector

- Observation of high multiplicity cosmic muon bundles (one event with > 100 muons every 5 days)
- Primary energy corresponding to ALICE events $10^{13} < E < 10^{18}$ eV

The natural accelerator



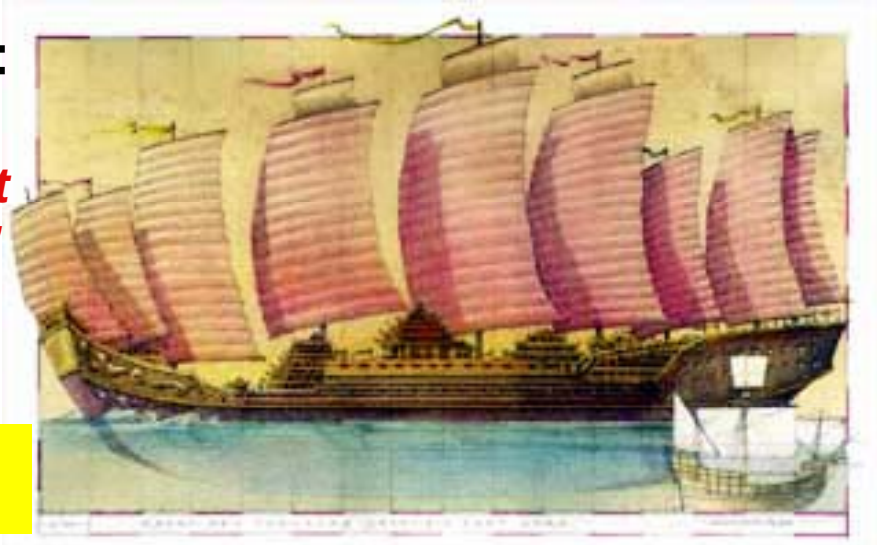
276 muons



136 muons

Science beyond curiosity

- History shows that it is **fundamental research** that **drives the development and progress of Society**, that the success of a civilization is linked to its support to science:
  - Greek civilisation (first to define the search for knowledge as a value);
  - Pre-medieval Arabic civilization;
  - 15th century Chinese civilization:
    - Debate between Eunuchs and Confucianists: ***"Why go look at what's going on elsewhere?"***



The size of Zheng He's armada was not exceeded for five centuries.(28000 sailors, 300 ships (some 130 m long)

Quotes from Casimir

- *"Certainly, one might speculate idly whether **transistors** might have been discovered by people who had not been trained in and had not contributed to wave mechanics or the quantum theory of solids. It so happened that William Shockley, John Bardeen and Walter Houser Brattain, the inventors of transistors in 1947 were versed in and contributed to the quantum theory of solids."*

- *"One might ask whether **basic circuits in computers** might have been found by people who wanted to build computers. As it happens, they were discovered in the thirties by physicists dealing with the counting of nuclear particles because they were interested in nuclear physics."* 1943: J.-P. Eckert and J. Mauchly build the first electronic computer Eniac (Electronic Numeral Integrator and Calculator)

etc. … Electronic industry, radio waves, laser, … Web

- **Satisfying human curiosity**, finding our place in the Universe, changing our reference frame, from **village**, **region**, **country**, **Earth**, to **Solar System**, **Milky Way**, **Local Group** of galaxies, etc.:

Where are we? How did we get here?

Only a few milestones

- **Eratosthenes of Cyrene** (⊕⟩⟨||∫∇∑|∫) 276-194 BC, Greek mathematician, poet, athlete, geographer, and astronomer;
- **Copernicus / Galileo Galilei** (16th century): new place of the Earth in the Universe (from geocentrism to heliocentrism) – a process that proved costly at that time (G. Bruno); Revolution in the method for answering questions! (400 years ago!)
- **Eratosthenes of Cyrene** (⊕⟩⟨||∫∇∑|∫) 276-194 BC;

Milestones

- **Copernicus / Galileo Galilei** (16th century): new place of the Earth in the Universe;
- **Einstein** (1905): relativity implying a new relation between space and time (i.e. cosmic muons, GPS);
- **Alexander Friedmann, Abbé Georges Lemaître, Edwin Hubble** (1929): the **expanding Universe**, as opposed to a static Universe, leading to the Big Bang model;
- Recent discovery that the **matter we are made of is only 4% of the contents of the Universe** (we are a minority);
- Realization that **space & time were perhaps both created in the Big Bang** (difficult even for physicists)
- Discovery of the **Higgs field**

Other milestones

- **Charles Robert Darwin** (1859): "on the Origin of Species" (idea of continuity of living species through evolution) ;
- **Crick and Watson** (1953): double helix structure of DNA, the fundamental molecules of life (Chemistry → Life)