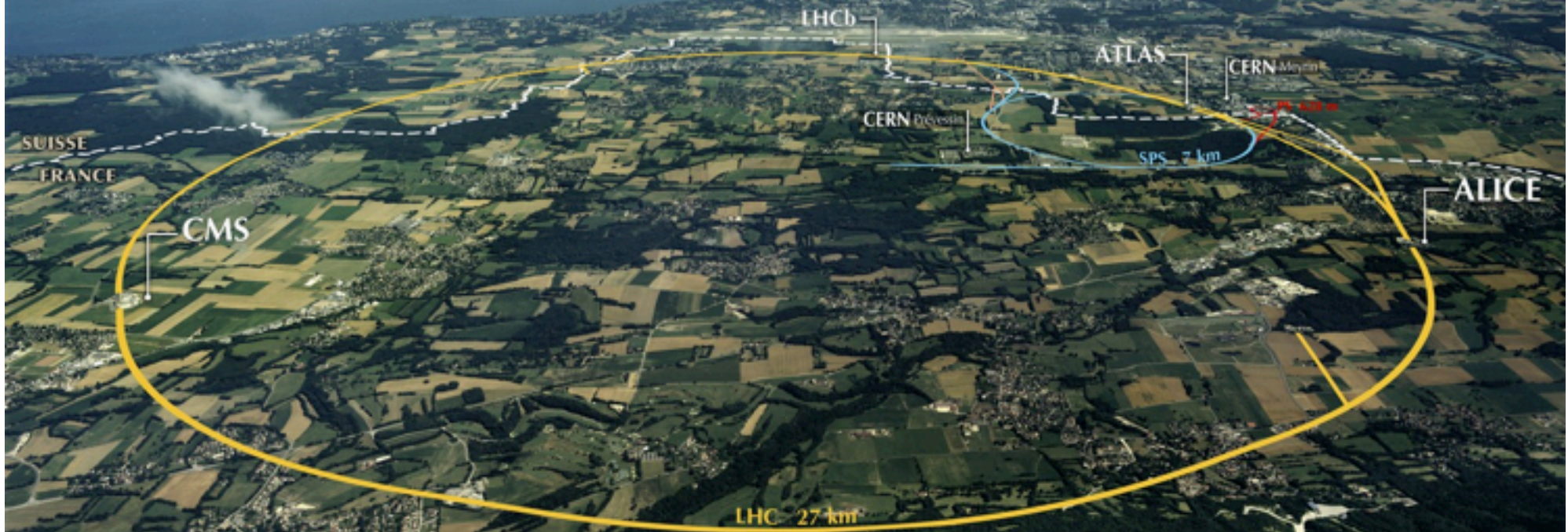


# Der Large Hadron Collider (LHC) am CERN: Unmögliches möglich und Unsichtbares sichtbar machen



Rotary Club Zürich  
5 November 2010  
Felicitas Pauss  
ETH Zürich / CERN





# CERN and Particle Physics is about ....

- **interfacing** between fundamental science and long-term technological development
- **generating new knowledge** about our surrounding Cosmos
- **training of scientists and engineering** to the benefit of Member States and their industries
- **contributing to paradigm shifts**, not incremental or linear progress (Web, Grid, PET, MRI, etc.)



# CERN and Particle Physics is about ....

Refining candles would not have led  
candles into electric bulbs ...





# CERN was founded 1954: 12 European States Today: 20 Member States



- ~ 2300 staff
- ~ 790 other paid personnel
- > 10000 users
- Budget (2010) ~1100 MCHF

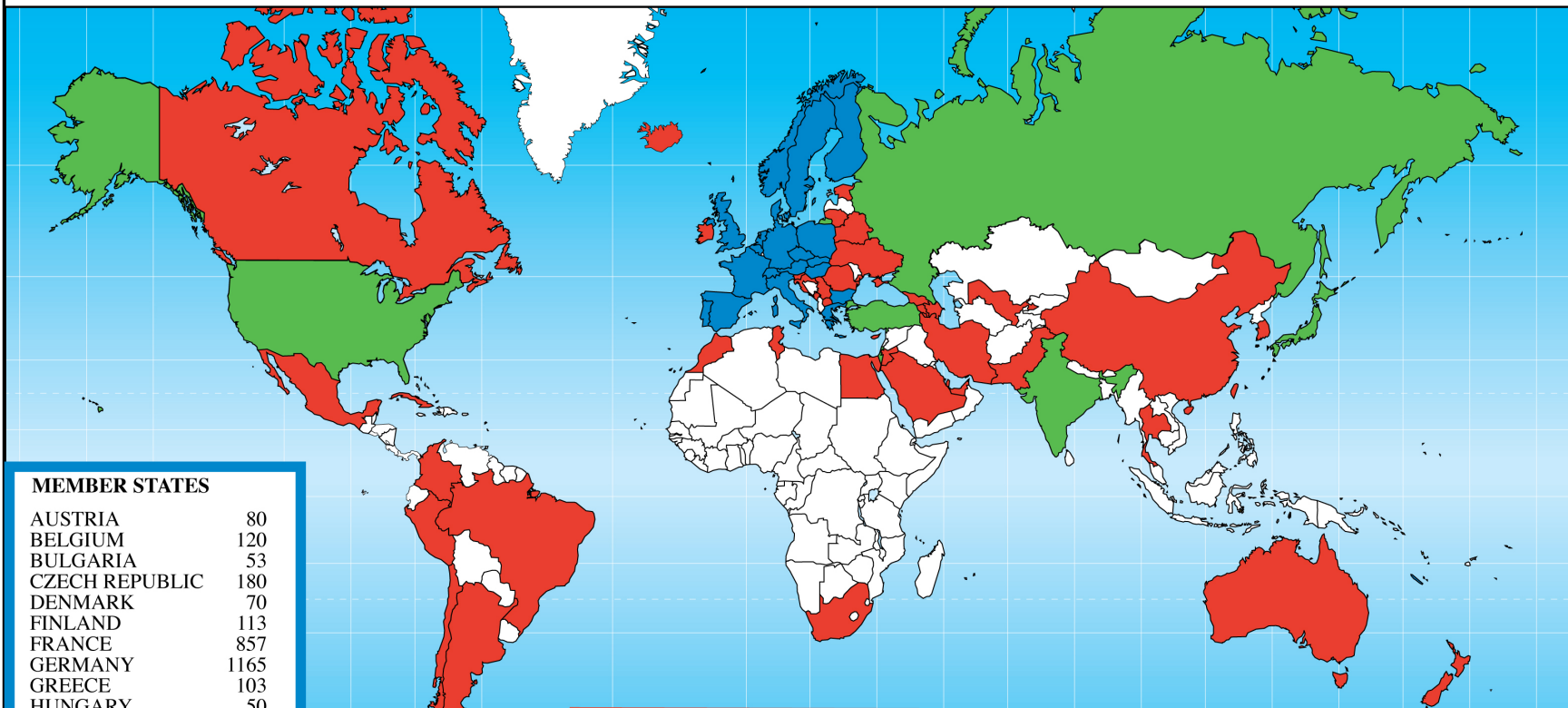
- **20 Member States:** Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.
- **8 Observers to Council:** India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO



# CERN in Numbers



## Distribution of All CERN Users by Nation of Institute on 2 July 2010



### MEMBER STATES

AUSTRIA	80
BELGIUM	120
BULGARIA	53
CZECH REPUBLIC	180
DENMARK	70
FINLAND	113
FRANCE	857
GERMANY	1165
GREECE	103
HUNGARY	50
ITALY	1409
NETHERLANDS	170
NORWAY	87
POLAND	189
PORTUGAL	137
SLOVAKIA	59
SPAIN	318
SWEDEN	70
SWITZERLAND	378
UNITED KINGDOM	713

### OBSERVER STATES

INDIA	106
ISRAEL	46
JAPAN	177
RUSSIA	849
TURKEY	77
USA	1774

### OTHERS

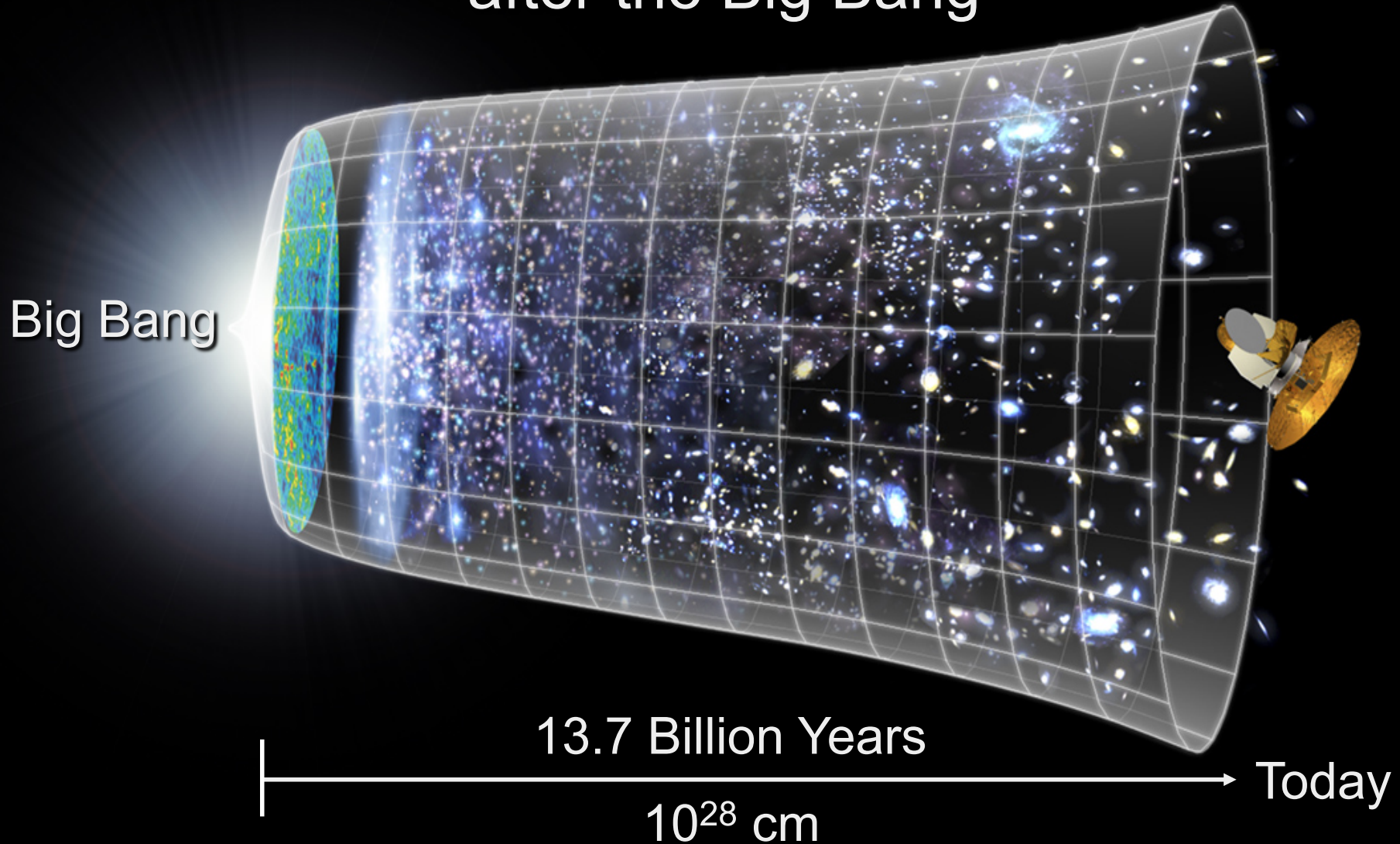
ARGENTINA	9	CROATIA	15	MACEDONIA, F.Y.R.	1	SERBIA	22
ARMENIA	13	CUBA	4	MALTA	1	SLOVENIA	24
AUSTRALIA	18	CYPRUS	8	MEXICO	35	SOUTH AFRICA	8
AZERBAIJAN	1	EGYPT	5	MONTENEGRO	1	THAILAND	2
BELARUS	22	ESTONIA	11	MOROCCO	6	TUNISIA	1
BRAZIL	79	GEORGIA	10	NEW ZEALAND	10	UKRAINE	17
CANADA	159	ICELAND	1	PAKISTAN	19	U.A.E.	1
CHILE	5	IRAN	16	PALESTINIAN TERR.	1	UZBEKISTAN	1
CHINA	77	IRELAND	13	PERU	2		
CHINA (TAIPEI)	49	KOREA	59	QATAR	1		
COLOMBIA	12	JORDAN	1	ROMANIA	58		
		LITHUANIA	10	SAUDI ARABIA	1		

**6321**

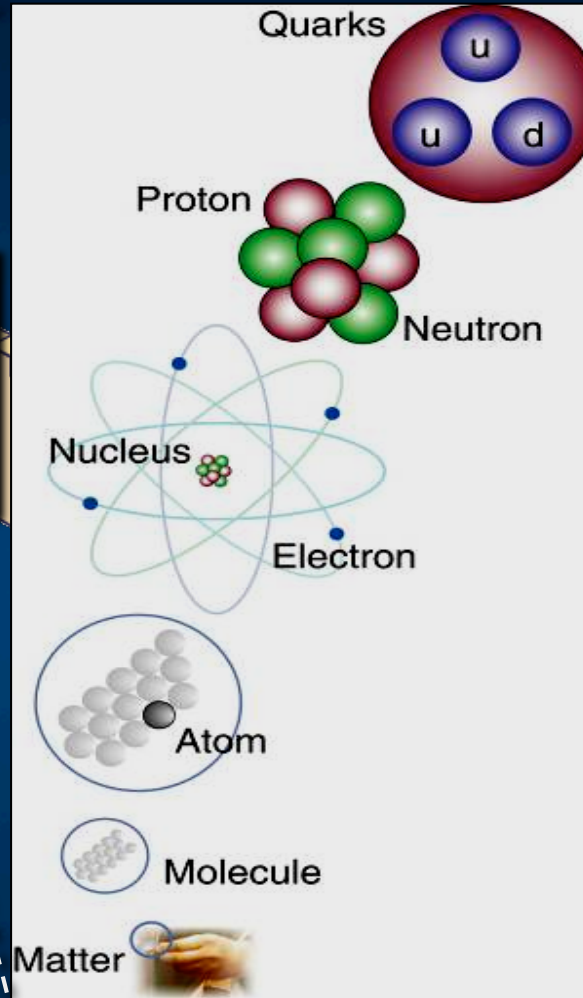
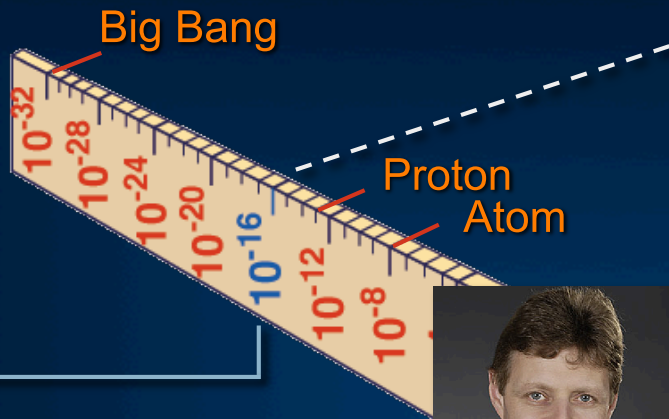
**3029**

**810**

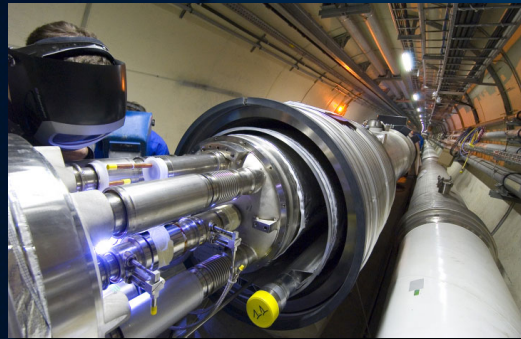
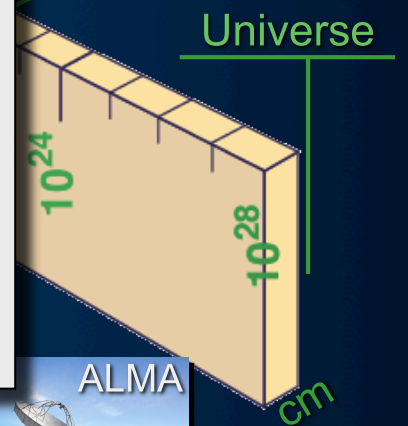
# Next Challenge: to understand the very first moments of our Universe after the Big Bang







Radius of Galaxies



LHC

Super-Microscope



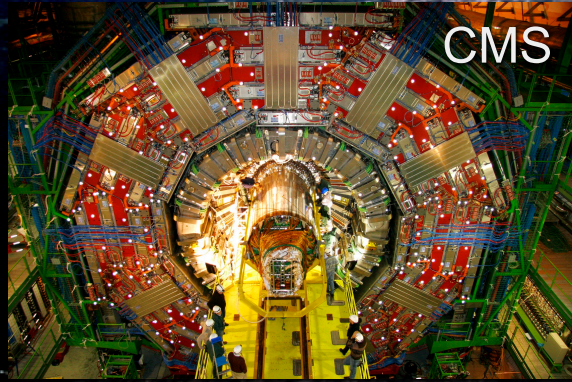
Study physics laws of first moments after Big Bang increasing Symbiosis between Particle Physics, Astrophysics and Cosmology



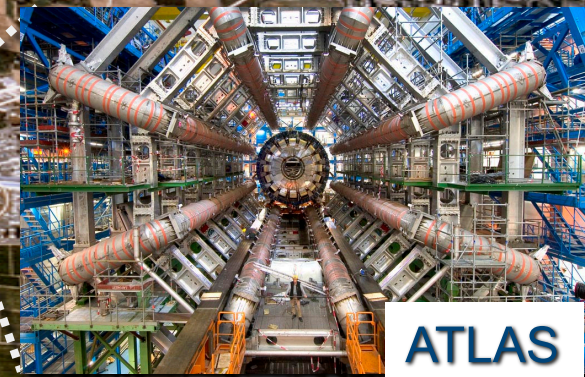


# Enter a New Era in Fundamental Science

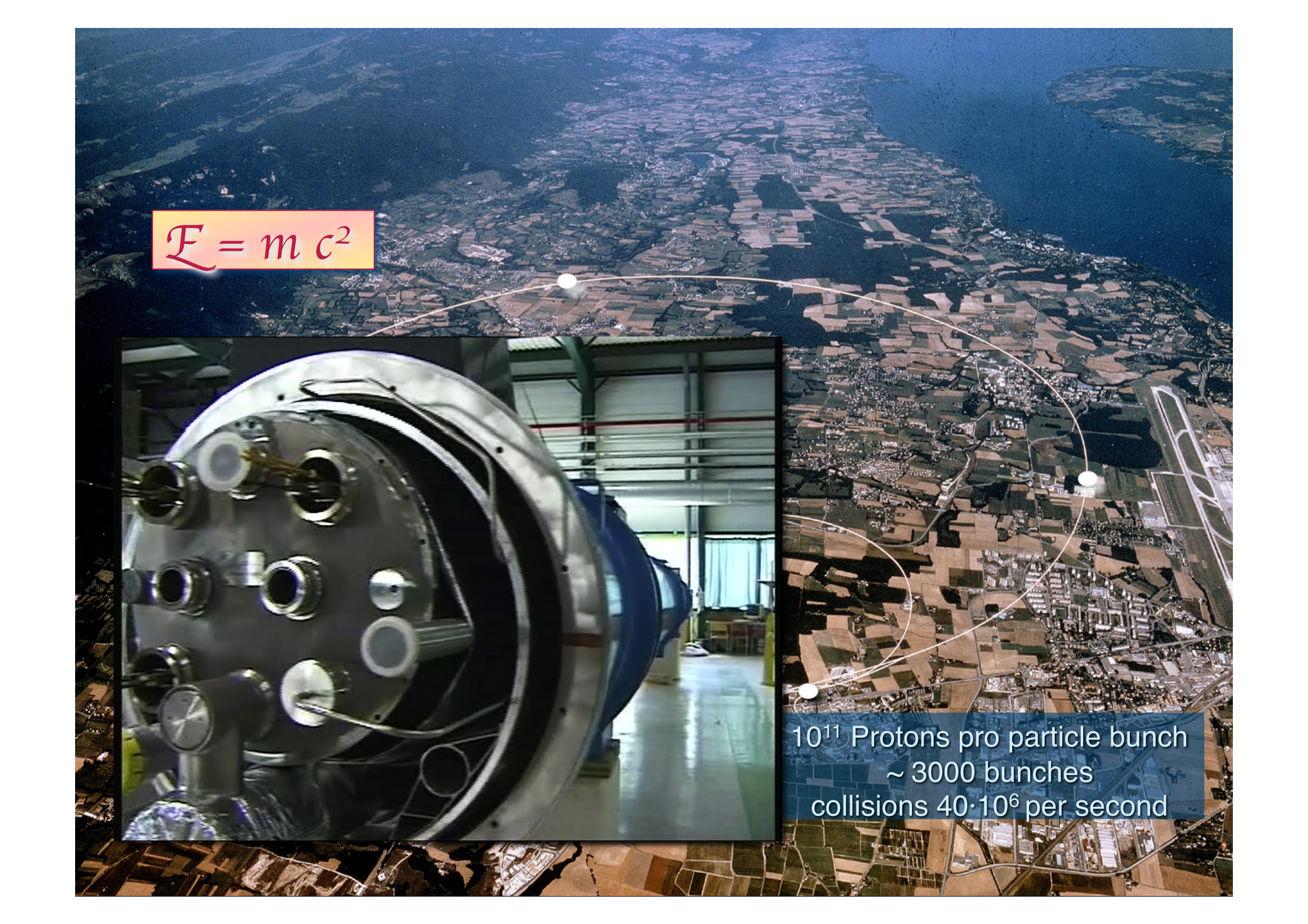
Start-up of the Large Hadron Collider (LHC), one of the largest and truly global scientific projects ever, is the most exciting turning point in particle physics.

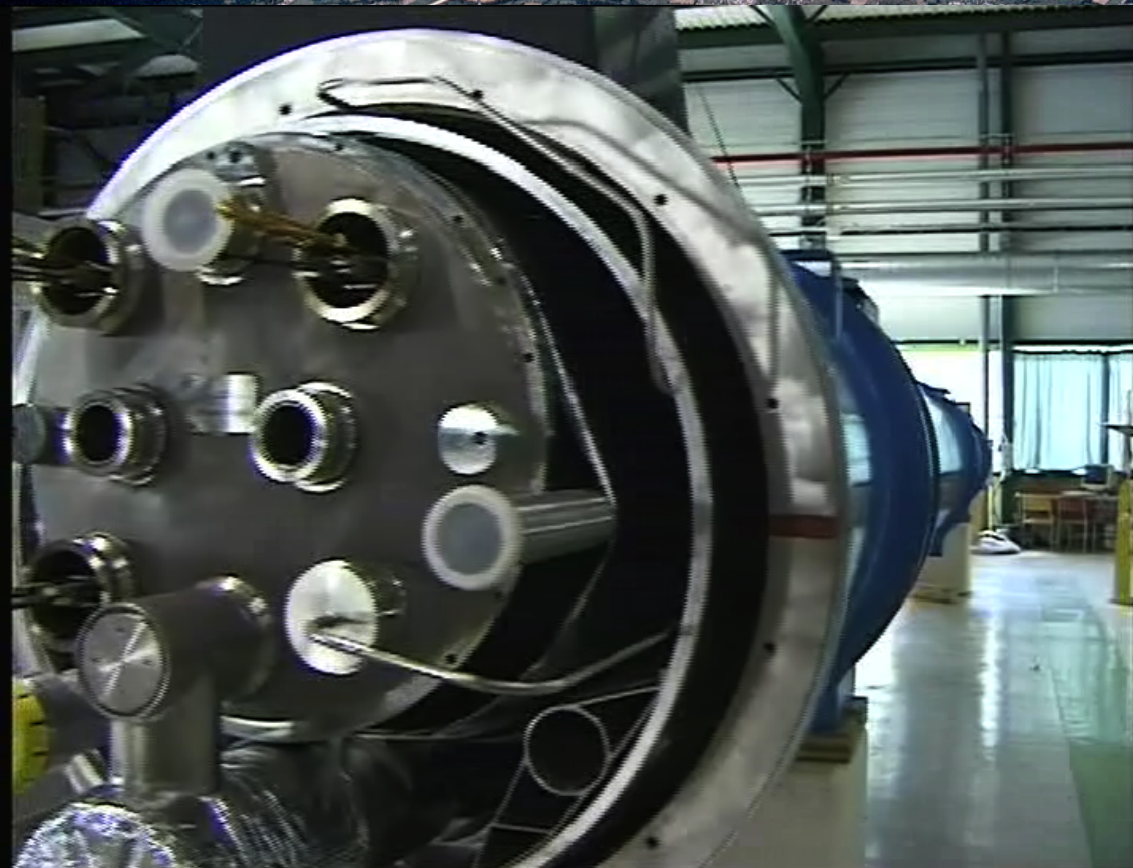


Exploration of a new energy frontier





An aerial photograph of a rural landscape with fields and a town. A white line representing a particle accelerator path is overlaid on the image, with three white dots marking specific locations. The equation  $E = mc^2$  is displayed in a red box in the upper left.
$$E = mc^2$$



$10^{11}$  Protons pro particle bunch  
~ 3000 bunches  
collisions  $40 \cdot 10^6$  per second





The CMS detector comprises many layers, each designed to perform a specific task.

These layers allow to identify and precisely measure the energies and momenta of all particles produced in collisions at LHC

Each collision produces many hundreds of particles

Design proton energy =  $7 \cdot 10^{12}$  eV (7 TeV)



$R \sim 10^{-13}$  cm

$M \sim 10^{-27}$  kg

$v \sim c$

$E = 7 \cdot 10^{12}$  eV



Length  $\sim 1$  cm

$M \sim 10^{-6}$  kg

$v \sim 1$  km/h

$E \sim 10^{12}$  eV

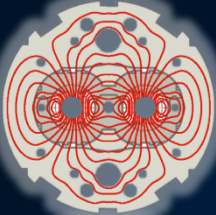
**~ 100 Million detecting elements**

**→ 40 million digital pictures per second**

Different layers have to operate for many years with little or no intervention

⇒ cutting-edge technologies





# LHC: First collisions at 7 TeV on 30 March 2010

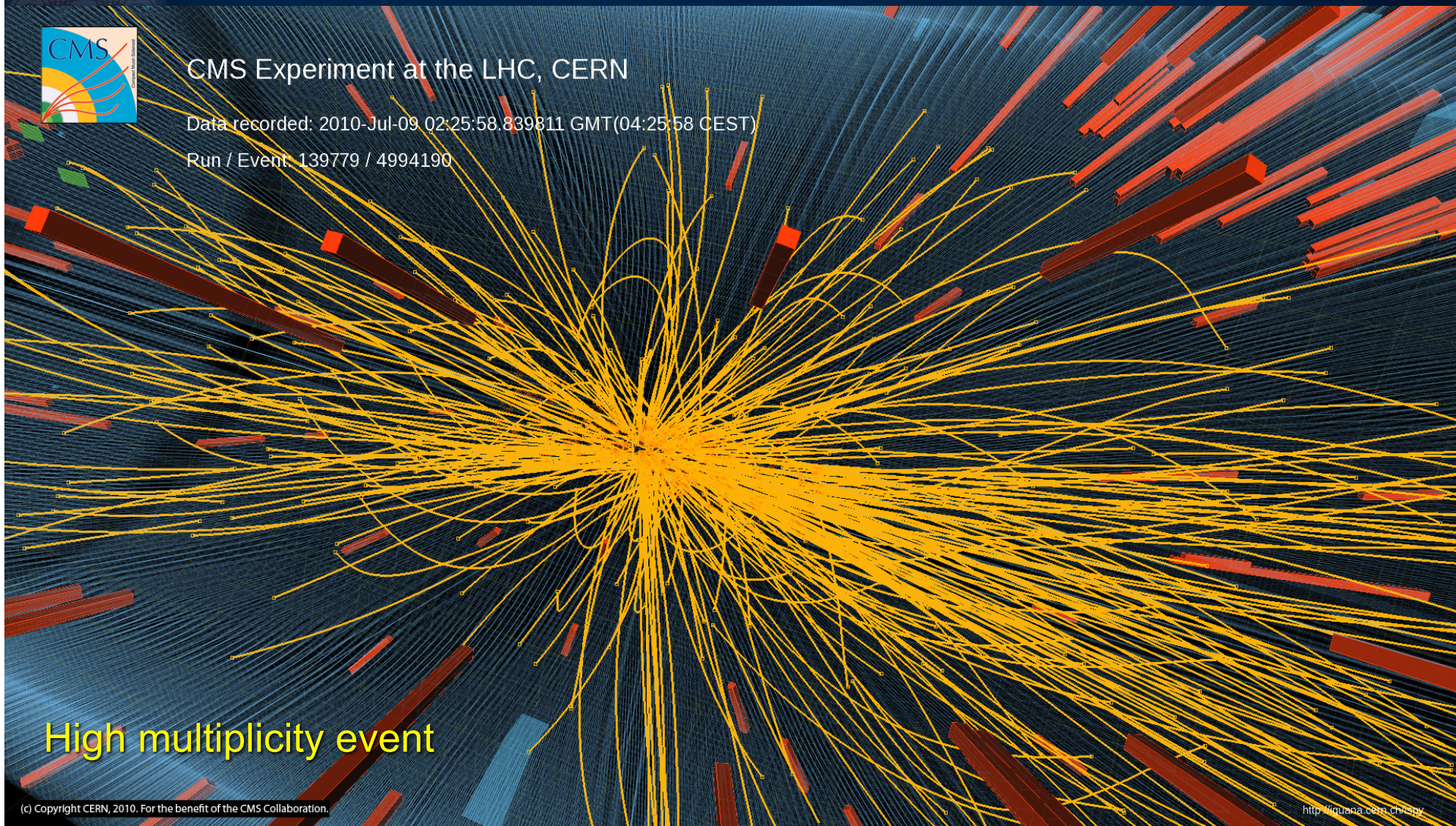
## Excellent performance of LHC and experiments



CMS Experiment at the LHC, CERN

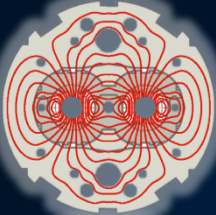
Data recorded: 2010-Jul-09 02:25:58.839811 GMT(04:25:58 CEST)

Run / Event: 139779 / 4994190



High multiplicity event





# WLCG: World LHC Computing Grid

File Edit View Tools Add Help

Oct 26, 2010 4:50:00 pm

Running jobs: 117948.0  
Transfer rate: 4.94 GiB/sec

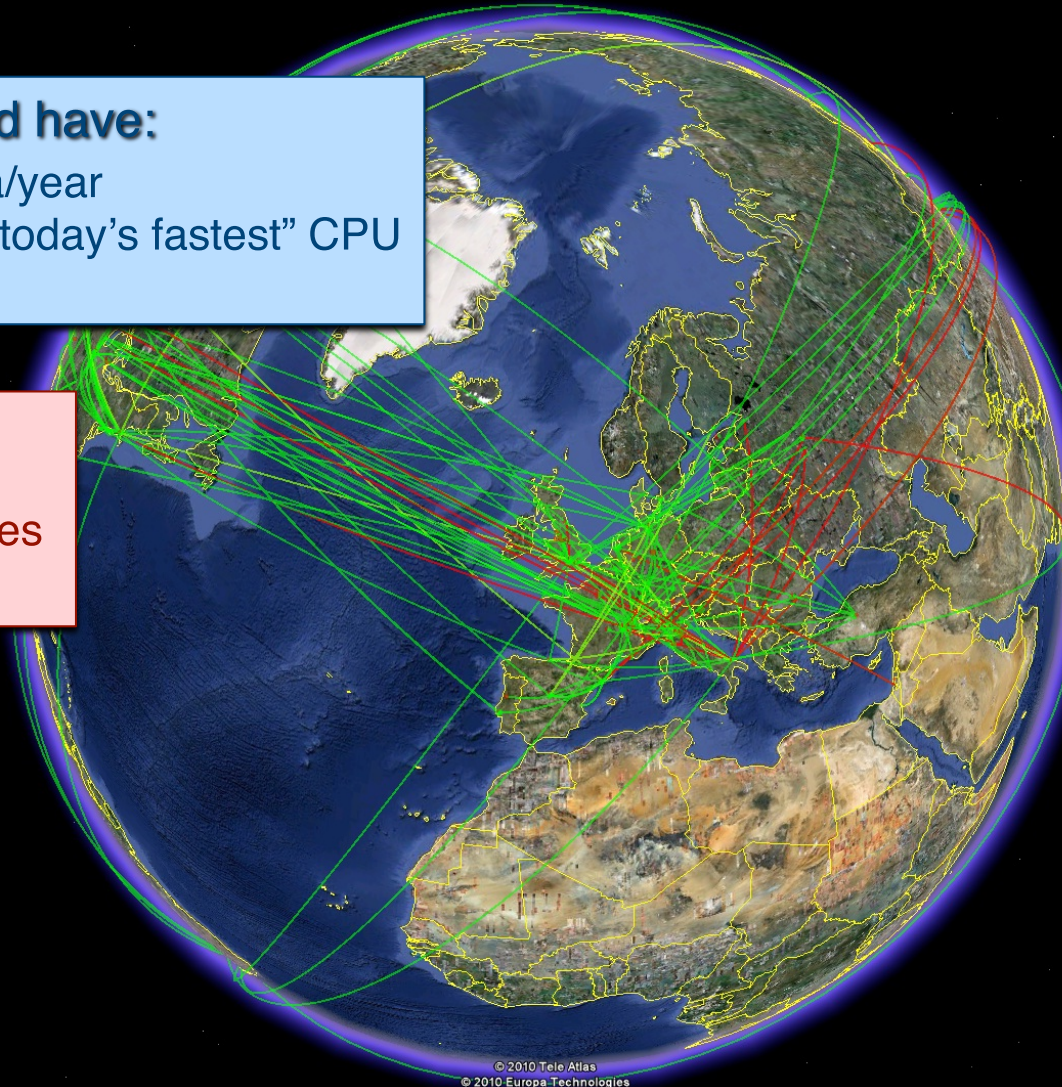


## We said we would have:

- ✧ 15 PB new data/year
- ✧ 100 (or 200) k “today’s fastest” CPU
- ✧ 45 PB disk

## Today we have:

- ✧ >140 sites
- ✧ ~250k CPU cores
- ✧ ~100 PB disk



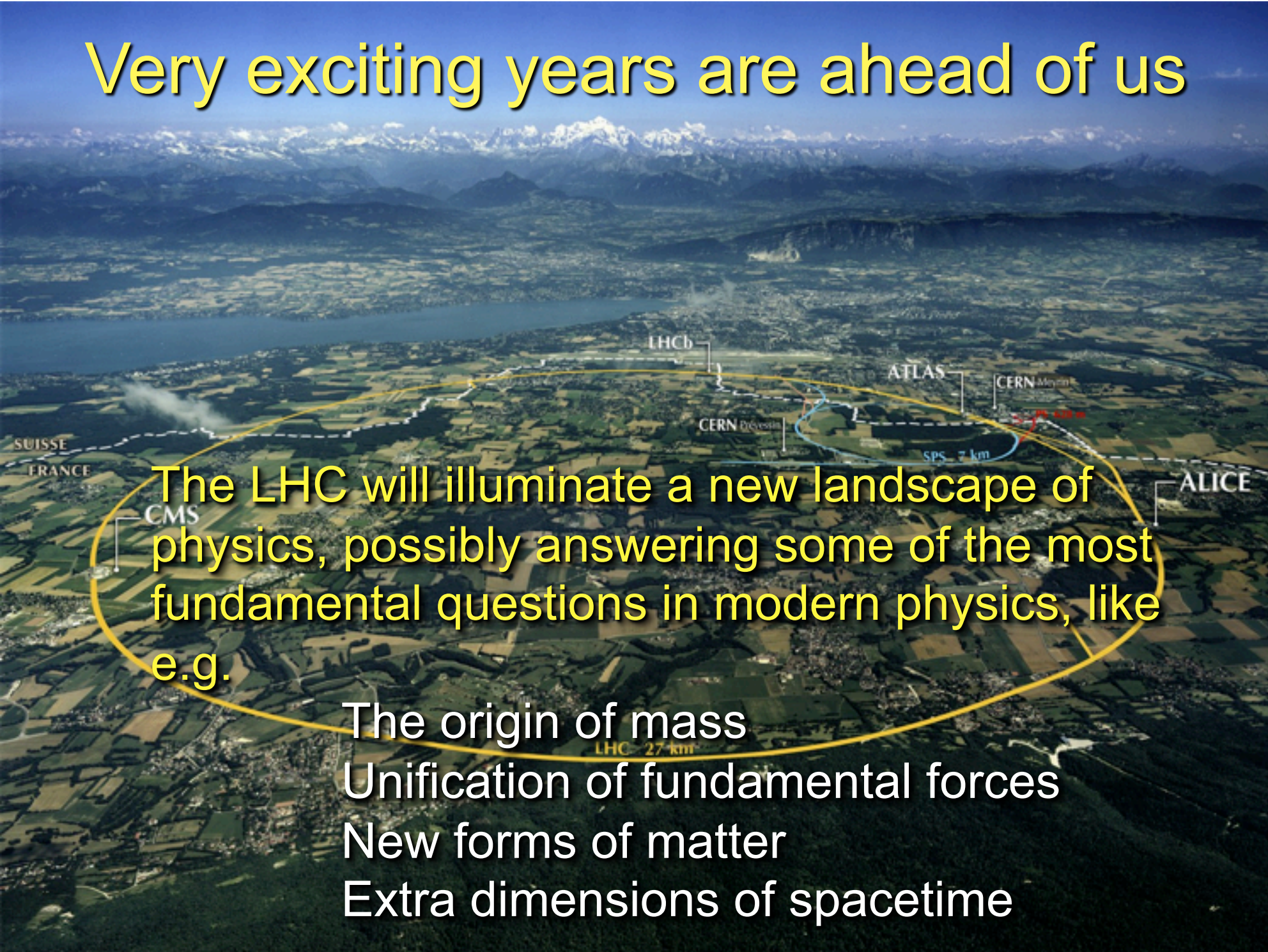
## Large numbers of analysis users

- ✧ CMS: ~800,
- ✧ ATLAS: ~1000,
- ✧ LHCb/ALICE: ~200
  
- ✧ 1 M jobs/day





# Very exciting years are ahead of us



The LHC will illuminate a new landscape of physics, possibly answering some of the most fundamental questions in modern physics, like e.g.

The image shows an aerial view of the CERN facility, with the LHC (Large Hadron Collider) highlighted in yellow. Other experiments shown include CMS, LHCb, ATLAS, ALICE, and the SPS (Super Proton Synchrotron). The LHC is labeled as 27 km long, and the SPS is labeled as 7 km long. The facility is located in the border region of Switzerland (SUISSE) and France (FRANCE). The background shows a vast landscape with mountains and a lake.

The origin of mass

Unification of fundamental forces

New forms of matter

Extra dimensions of spacetime



# Very exciting years are ahead of us



“ We are ready for an unforeseen event that may or may not occur”

(A. Gore)

# THANK YOU !!