

*Welcome – Murakaza neza - to CERN*

Global collaboration in Particle Physics  
Interesting for Rwanda?

Research &  
Discovery

Technology

Training

Collaboration





# CERN in Numbers 2009

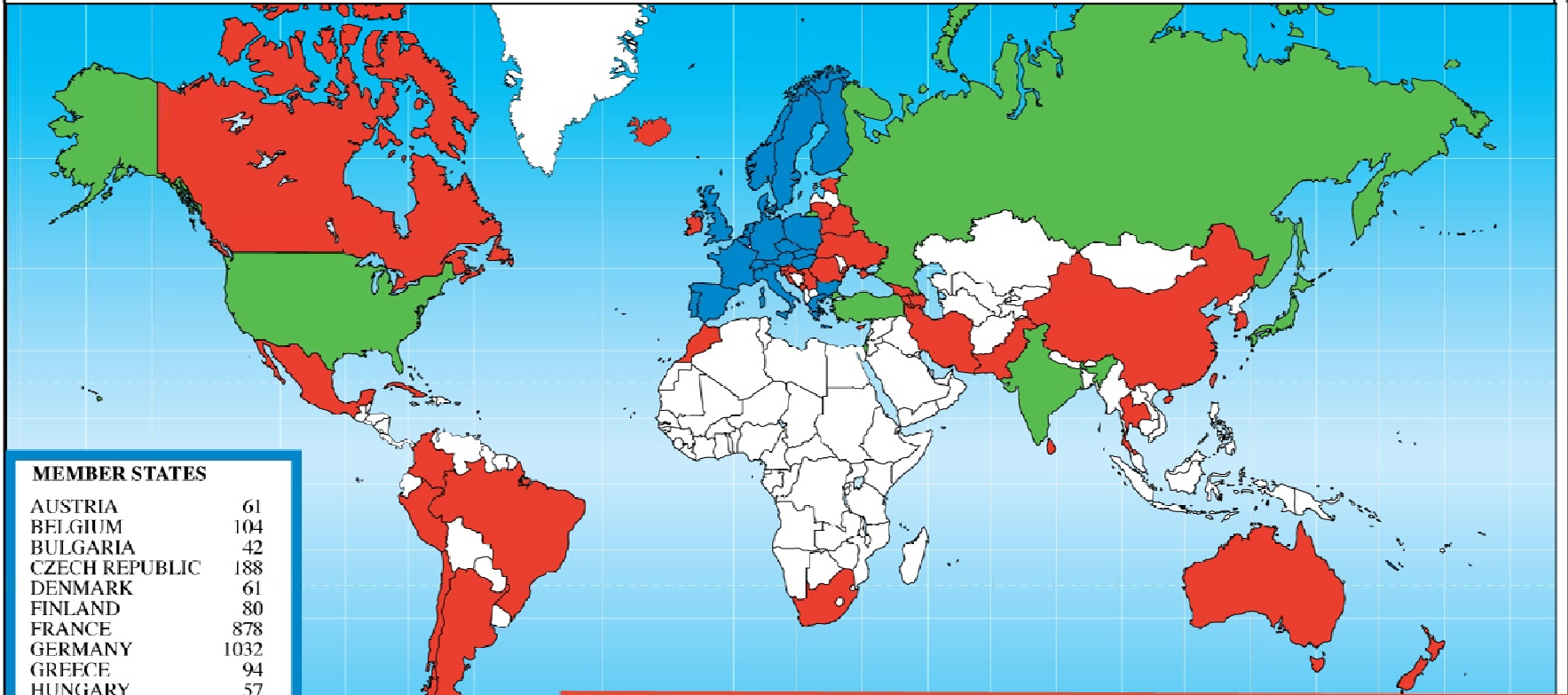


- 2256 staff
- ~700 other paid personnel
- ~9500 users
- Budget (2009) 1100 MCHF

- **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.
- **1 Candidate for Accession to Membership of CERN:** Romania
- **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 6 January 2009



### MEMBER STATES

AUSTRIA	61
BELGIUM	104
BULGARIA	42
CZECH REPUBLIC	188
DENMARK	61
FINLAND	80
FRANCE	878
GERMANY	1032
GREECE	94
HUNGARY	57
ITALY	1483
NETHERLANDS	175
NORWAY	78
POLAND	174
PORTUGAL	111
SLOVAKIA	49
SPAIN	286
SWEDEN	73
SWITZERLAND	330
UNITED KINGDOM	715

**6071**

### OBSERVER STATES

INDIA	89
ISRAEL	59
JAPAN	200
RUSSIA	883
TURKEY	52
USA	1485

**2768**

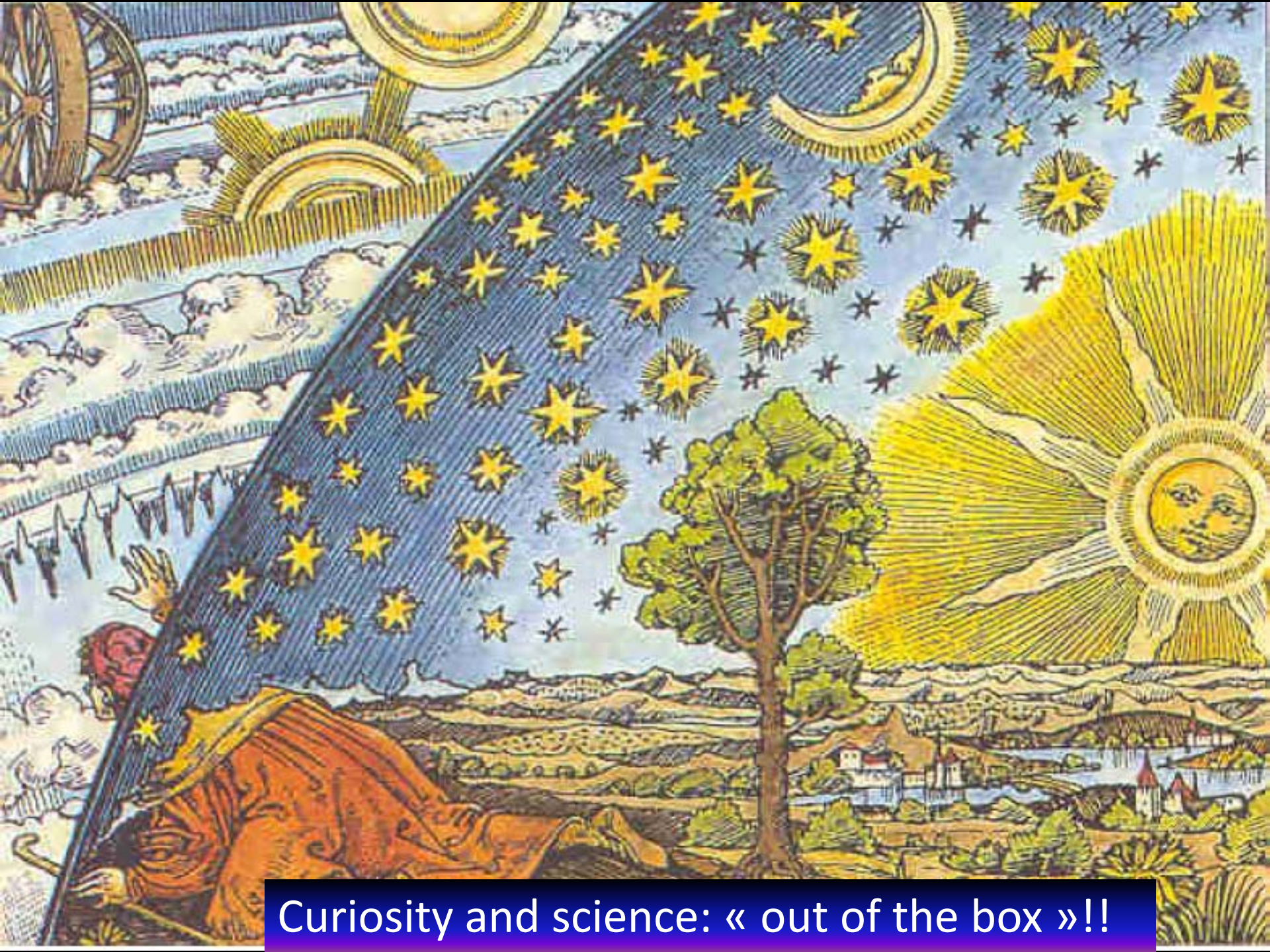
### OTHER STATES

ARGENTINA	10	CUBA	3	MONTENEGRO	1	SRI LANKA	1
ARMENIA	15	CYPRUS	6	MOROCCO	5	TAIWAN	42
AUSTRALIA	14	ESTONIA	11	NEW ZEALAND	6	THAILAND	1
AZERBAIJAN	1	GEORGIA	11	PAKISTAN	24	UKRAINE	18
BELARUS	19	ICELAND	1	PERU	1		
BRAZIL	73	IRAN	12	ROMANIA	49		
CANADA	136	IRELAND	12	SERBIA	17		
CHILE	4	KOREA	51	SLOVENIA	16		
CHINA	64	LITHUANIA	5	SOUTH AFRICA	8		
COLOMBIA	11	MEXICO	28				
CROATIA	20						

**696**

~70% of world particle physics population; change over 1500/year





Curiosity and science: « out of the box »!!



# Padova, 1609





# The revolutionary discovery

1610

Die 25. Julij. Summo maori Escto rumpit  
in Jacobi Die Gomines Potuui primu  
obseruati 7<sup>e</sup> orientali matub nū cui  
statant tres Placūs, Medici orientales  
ab ipso in hūc ordinē

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Die 29. iulij  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 2 & 3 & 3 & 1 & 4 \end{matrix}$

D. 5. Aug.  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 2 & 3 & 3 & 1 & 4 \end{matrix}$  med  
occidentali; haululu offerenti

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sup. i. Notion

D. 30.  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 6 & 20 & 190 & 12 & 1 \end{matrix}$  O orientalis  
2<sup>a</sup> hor. haululu i. hor. asellat, et cā 2<sup>a</sup> i.

D. 19. H noctij.  $\begin{matrix} * & * & * & * \\ \sim & \sim & \sim & \sim \\ 3 & 3 & 12 & 7 \end{matrix}$  O

D. 15. H. 5.  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 3 & 5 & 10 & 3 & 3 \end{matrix}$  O  
2<sup>a</sup> 7<sup>a</sup> sunt caliginos, ex pro occidentalis. fūllō  
conficiant

D. 18. H. 5.  $\begin{matrix} * & * & * & * \\ \sim & \sim & \sim & \sim \\ 3 & 7 & 7 & 7 \end{matrix}$  O

D. 19.  $\begin{matrix} * & * & * & * \\ \sim & \sim & \sim & \sim \\ 5 & 2 & 7 & 7 \end{matrix}$  O

D. 20. H. 5.  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 8 & 3 & 3 & 3 & 3 \end{matrix}$  O  
Bonae: et H. 7. 2. nūtiy 150. 7<sup>a</sup> capabāt

D. 21.  $\begin{matrix} * & * & * & * \\ \sim & \sim & \sim & \sim \\ 3 & 9 & 3 & 4 \end{matrix}$  O

D. 13. H. 3. 30.  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 1 & 4 & 20 & 1 & 1 \end{matrix}$  O. Secūda i. 4. i. hor.  
stellabatur.

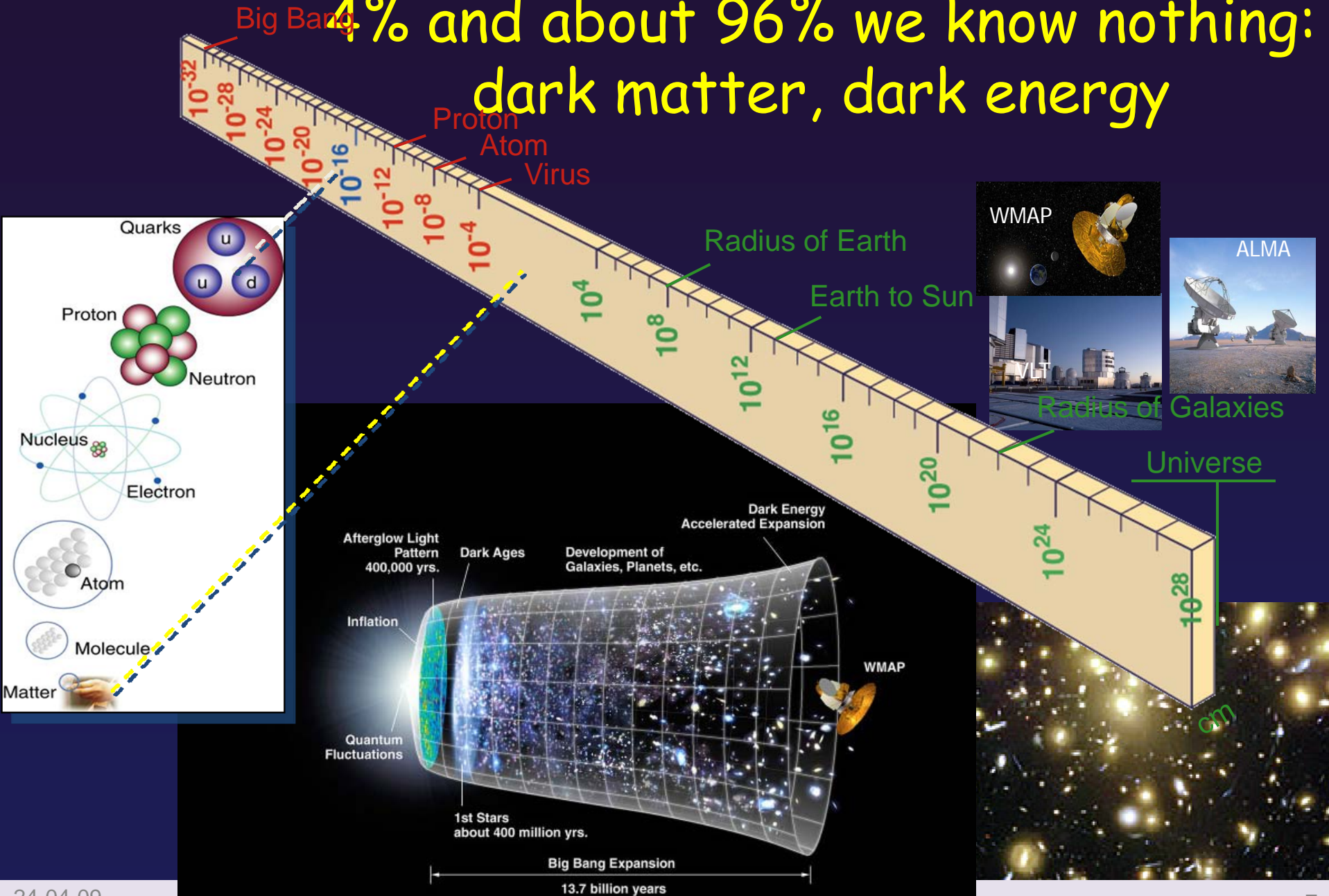
H. 7. mīā moty 7. cōtūreū fūllō  
H. 5.  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 2 & 3 & 3 & 3 & 3 \end{matrix}$  O medius i. dēbat' in  
auly. Dechnare

D. 14. H. 5. 50.  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 5 & 5 & 6 & 6 & 6 \end{matrix}$  O

D. 19. H. 7. 20.  $\begin{matrix} * & * & * & * & * \\ \sim & \sim & \sim & \sim & \sim \\ 1 & 40 & 150 & 8 & 1 \end{matrix}$  O  
logu' 3. arie dō po



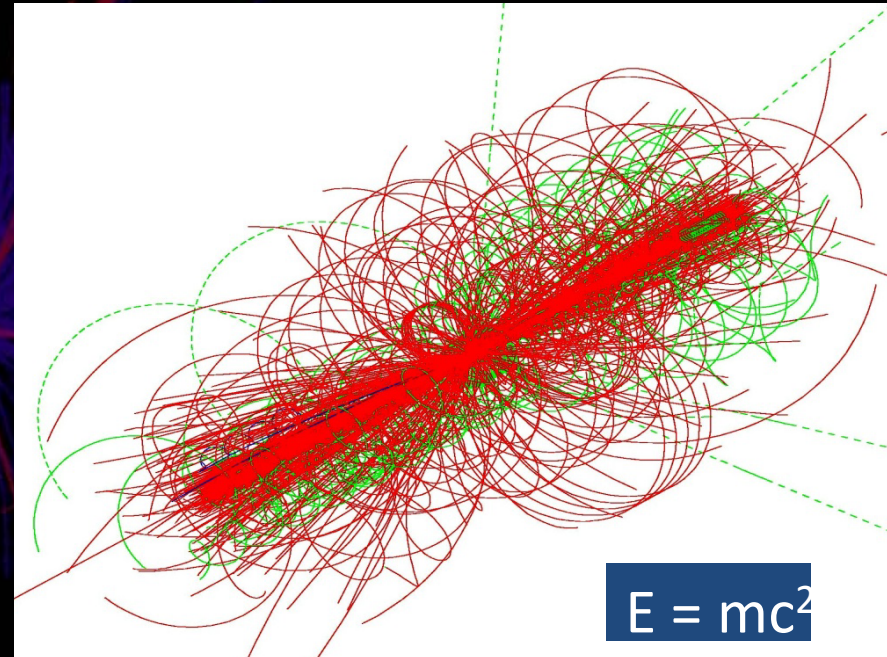
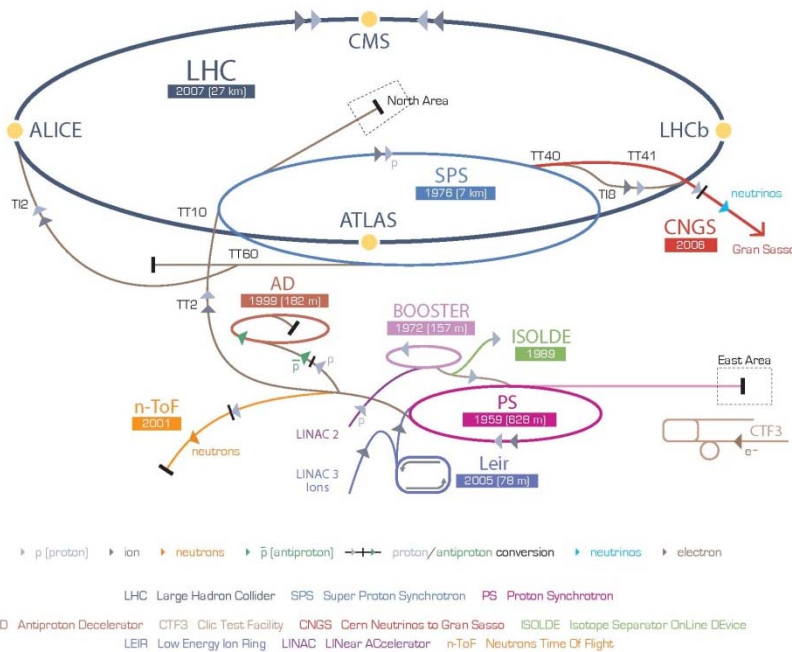
# 60 orders of magnitude: we know ~ 4% and about 96% we know nothing: dark matter, dark energy





# Particle Physics and CERN

Accelerators bring matter to extremely high temperatures and experiments observe the resulting decay products



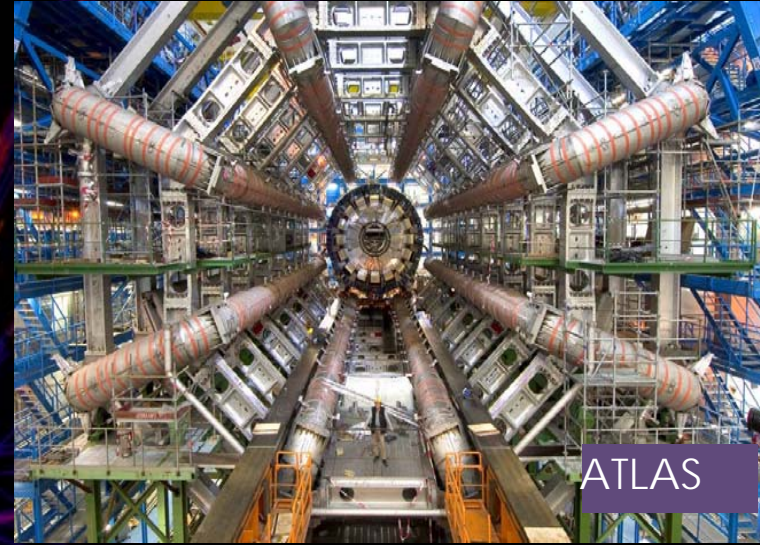
Objectives: what are the elementary particles (amongst them the constituents of dark matter), what are their properties and the forces acting between them, what are the differences of matter and antimatter, what is the origin of mass, how many dimensions are there, ... ?



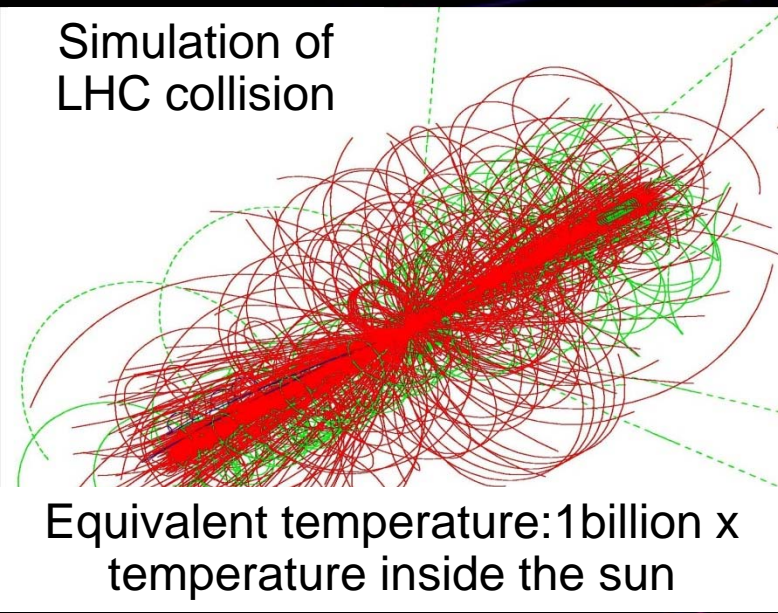
# Next step in Particle Physics: LHC



LHC ring:  
27 km circumference

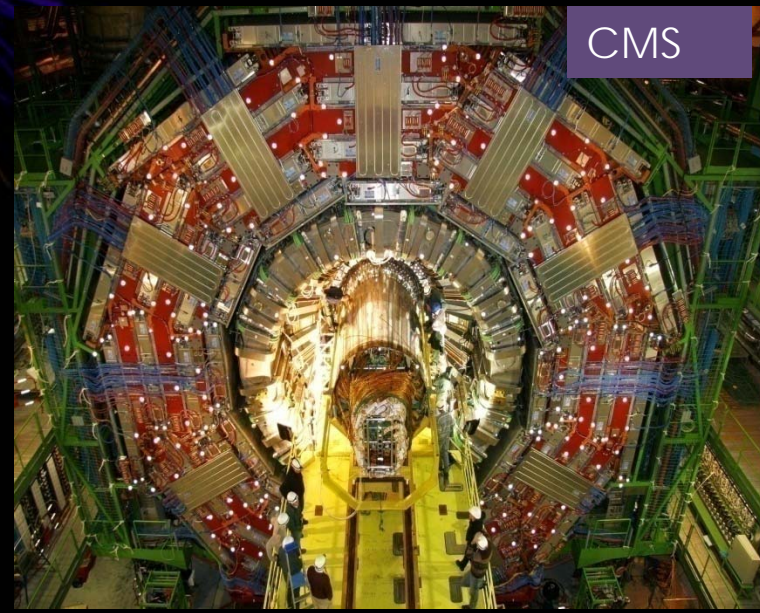


ATLAS



Simulation of  
LHC collision

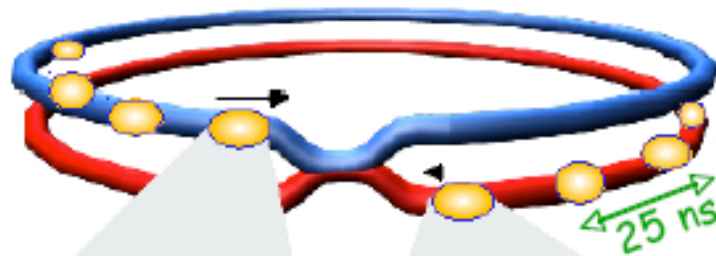
Equivalent temperature: 1 billion x  
temperature inside the sun



CMS



# Collisions at LHC



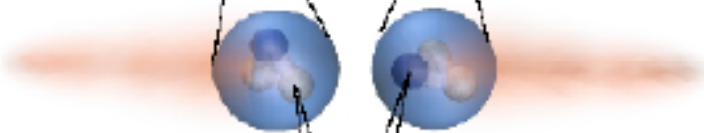
## Proton-Proton

Protons/bunch	$10^{11}$
Beam energy	7 TeV ( $7 \times 10^{12}$ eV)
Luminosity	$10^{34}$ cm <sup>-2</sup> s <sup>-1</sup>

Bunch



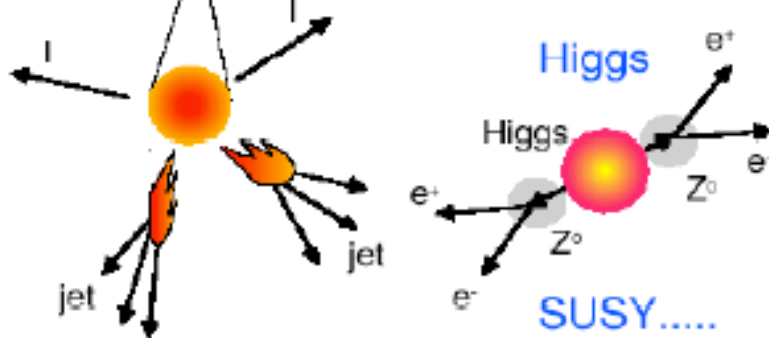
Proton



Parton  
(quark, gluon)



Particle



Event rate in ATLAS :

$$N = L \times \sigma (pp) \approx 10^9 \text{ interactions/s}$$

Mostly soft ( low  $p_T$  ) events

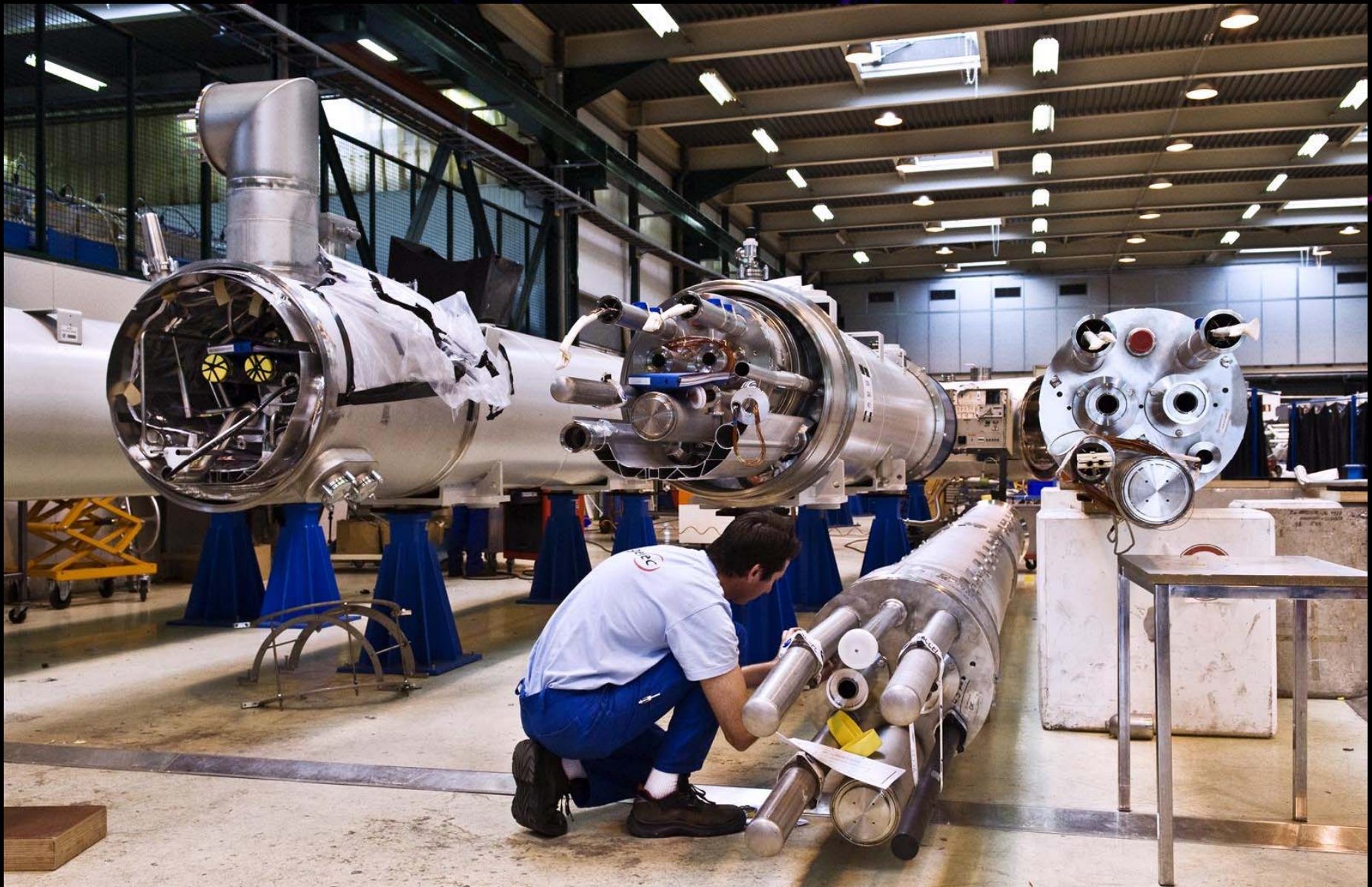
← Interesting hard (high- $p_T$  ) events are rare

**Selection of 1 in  
10,000,000,000,000**

SUSY.....



# LHC magnet assembly at CERN

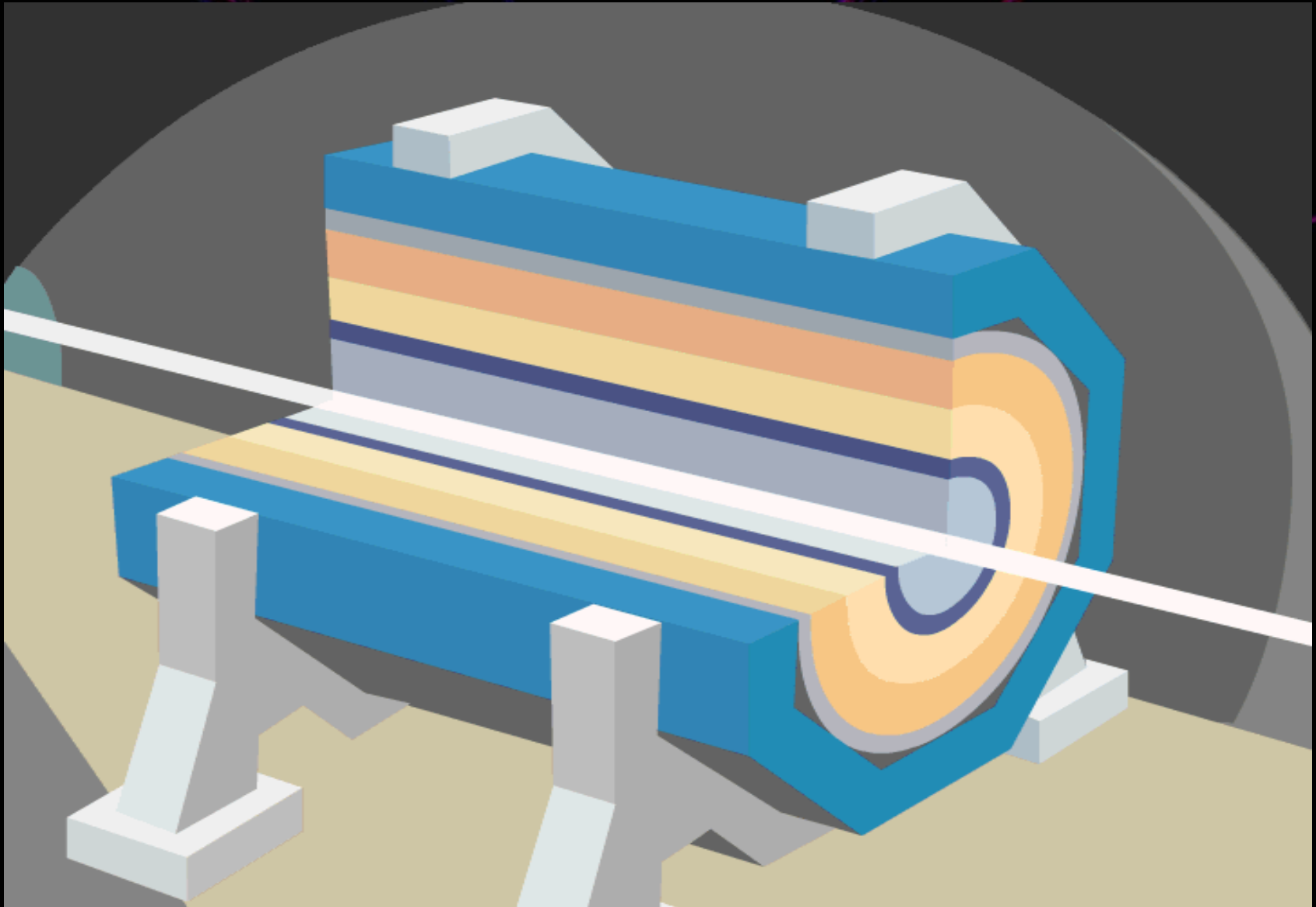






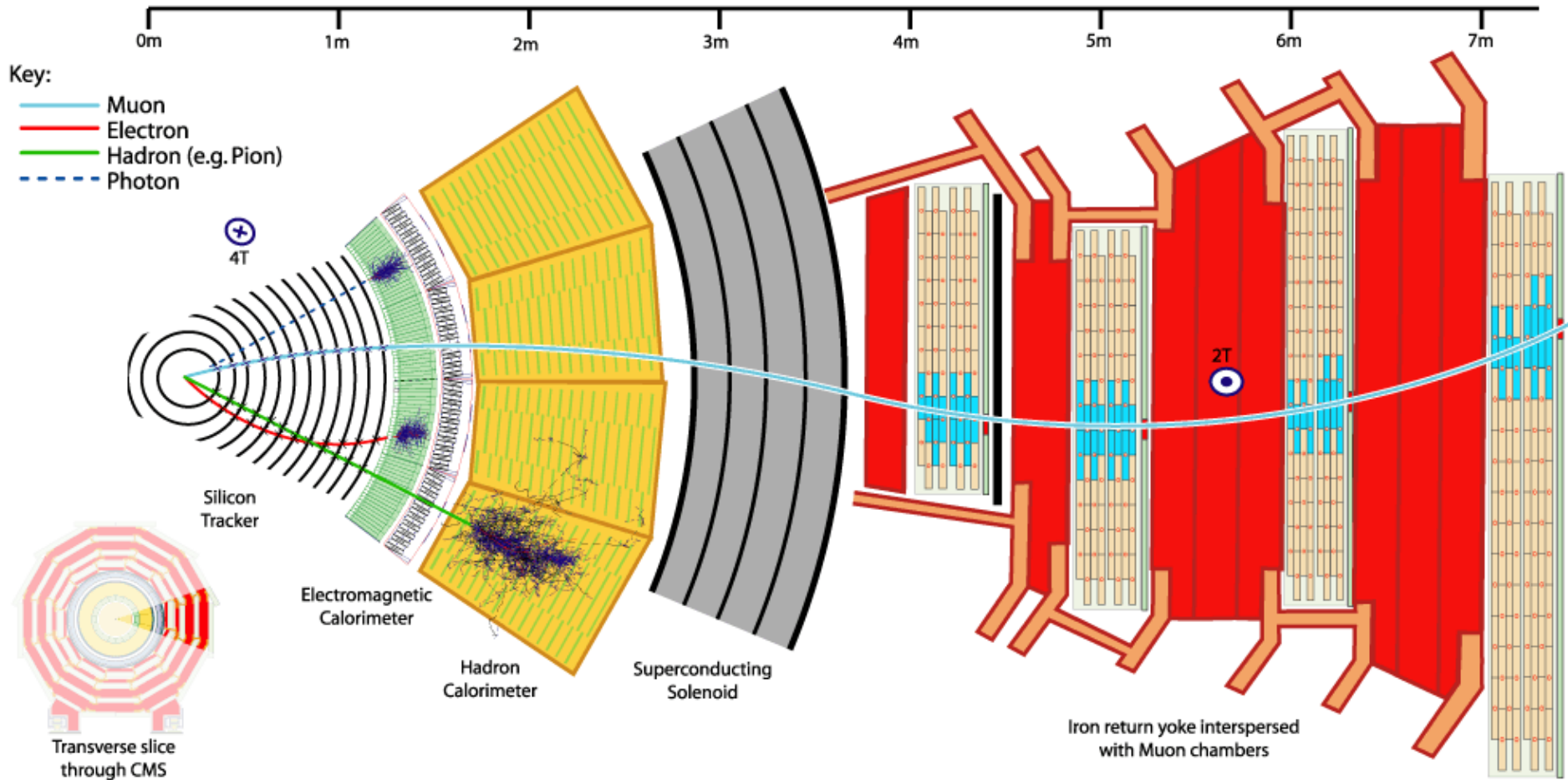


# Observe the collisions



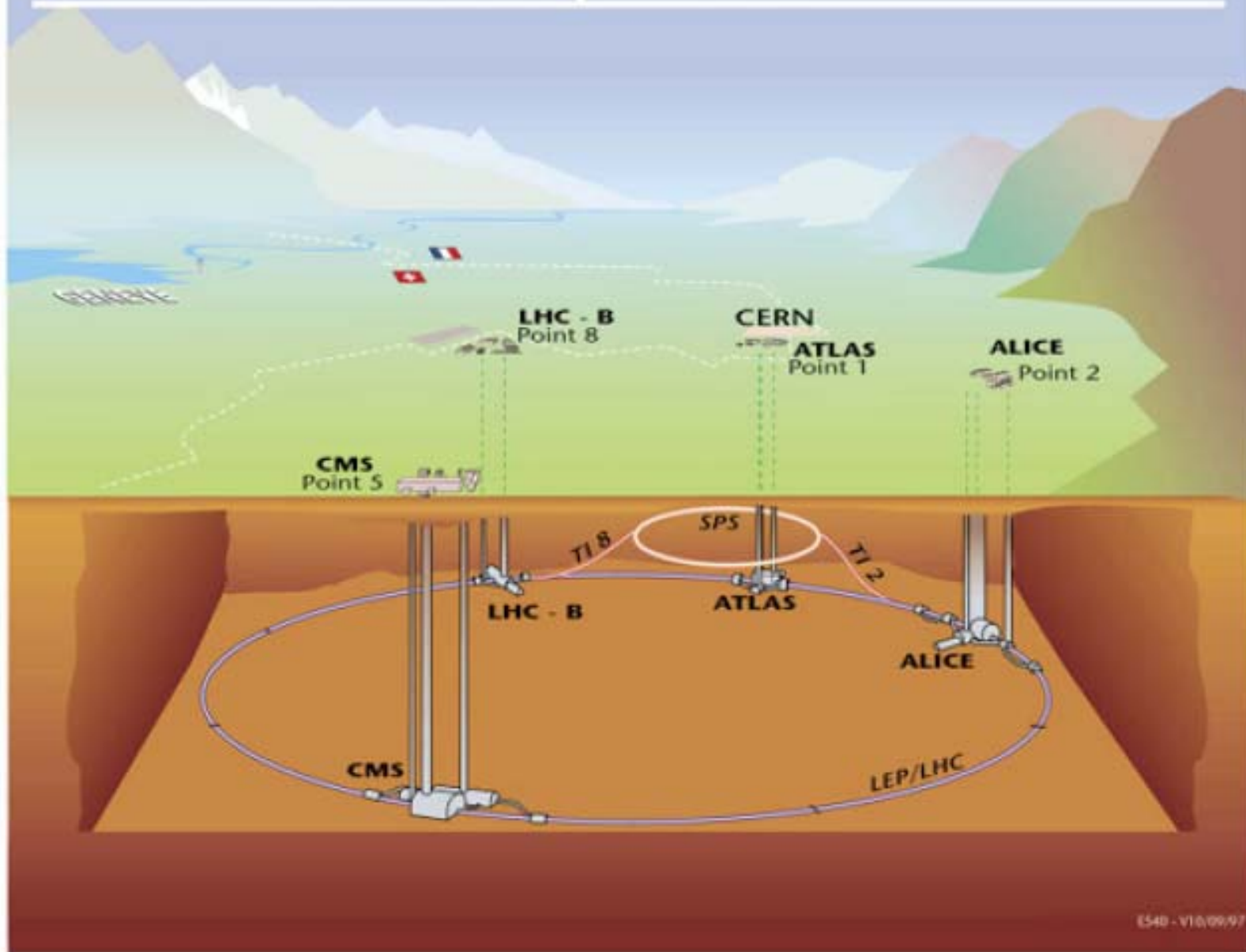


# CMS

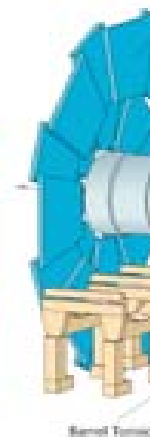




# Overall view of the LHC experiments.



E540 - V10/09/97



Tin Project Chamber

L1 Magnet

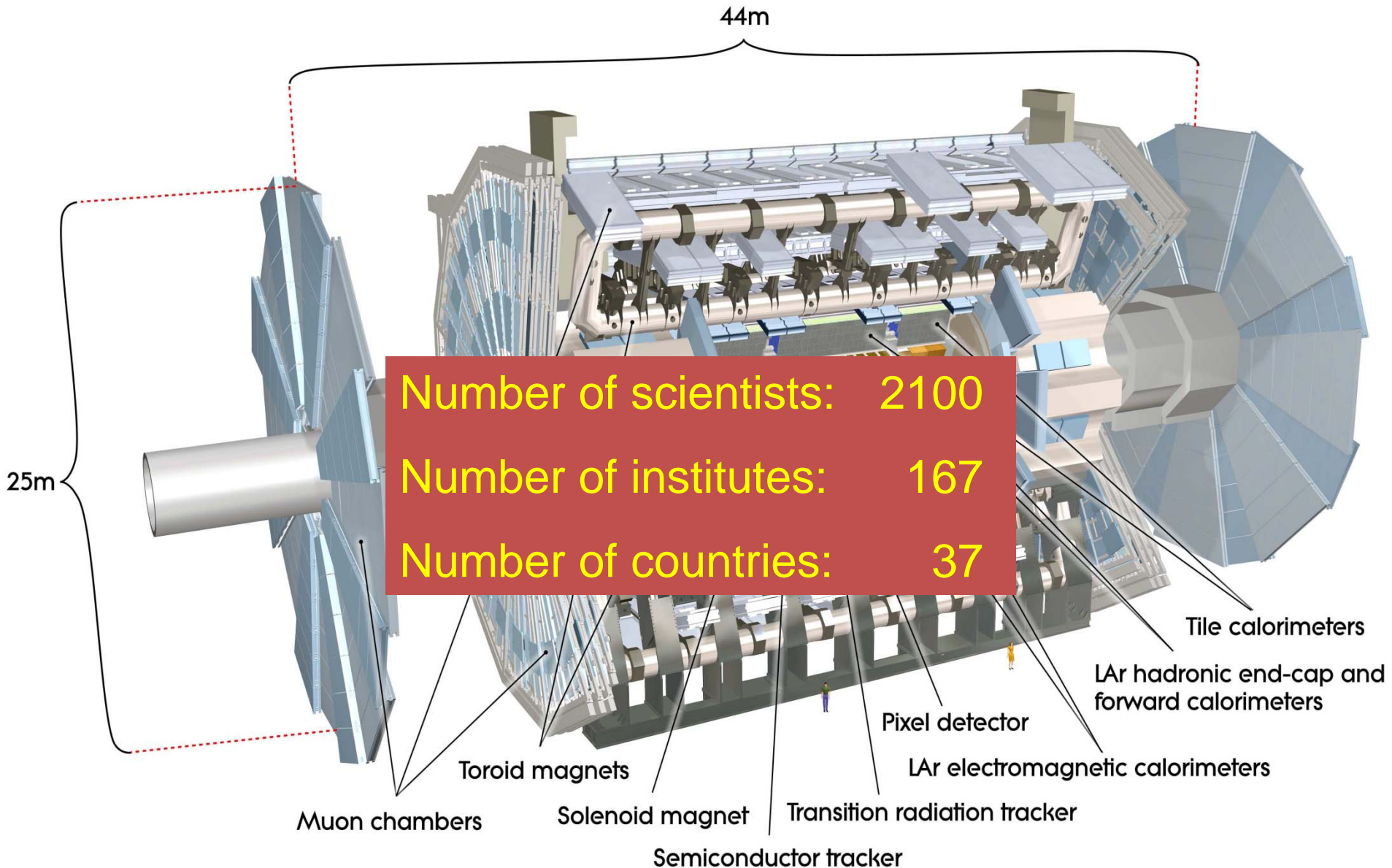
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# ATLAS (Spokesperson Fabiola Gianotti)

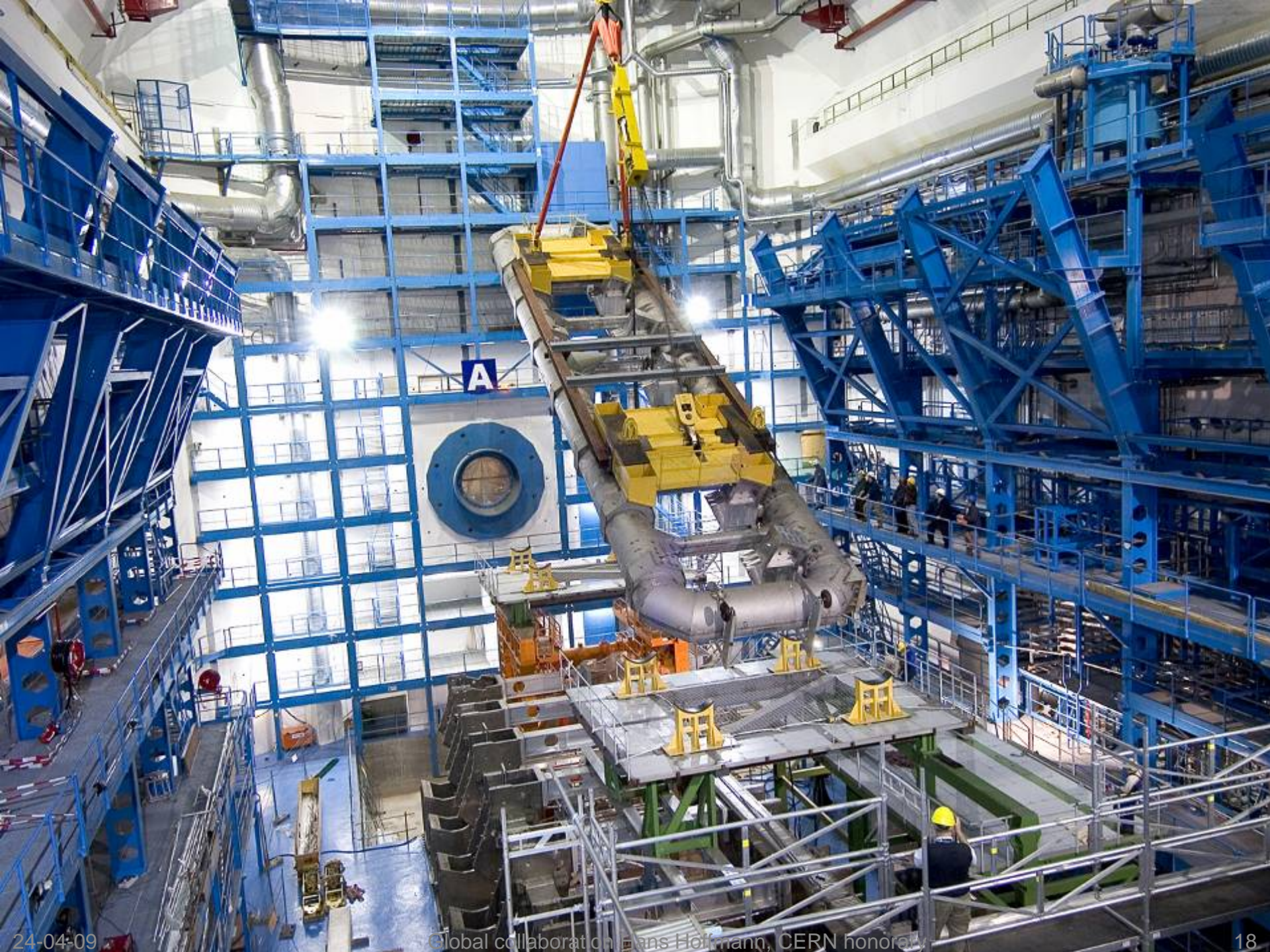




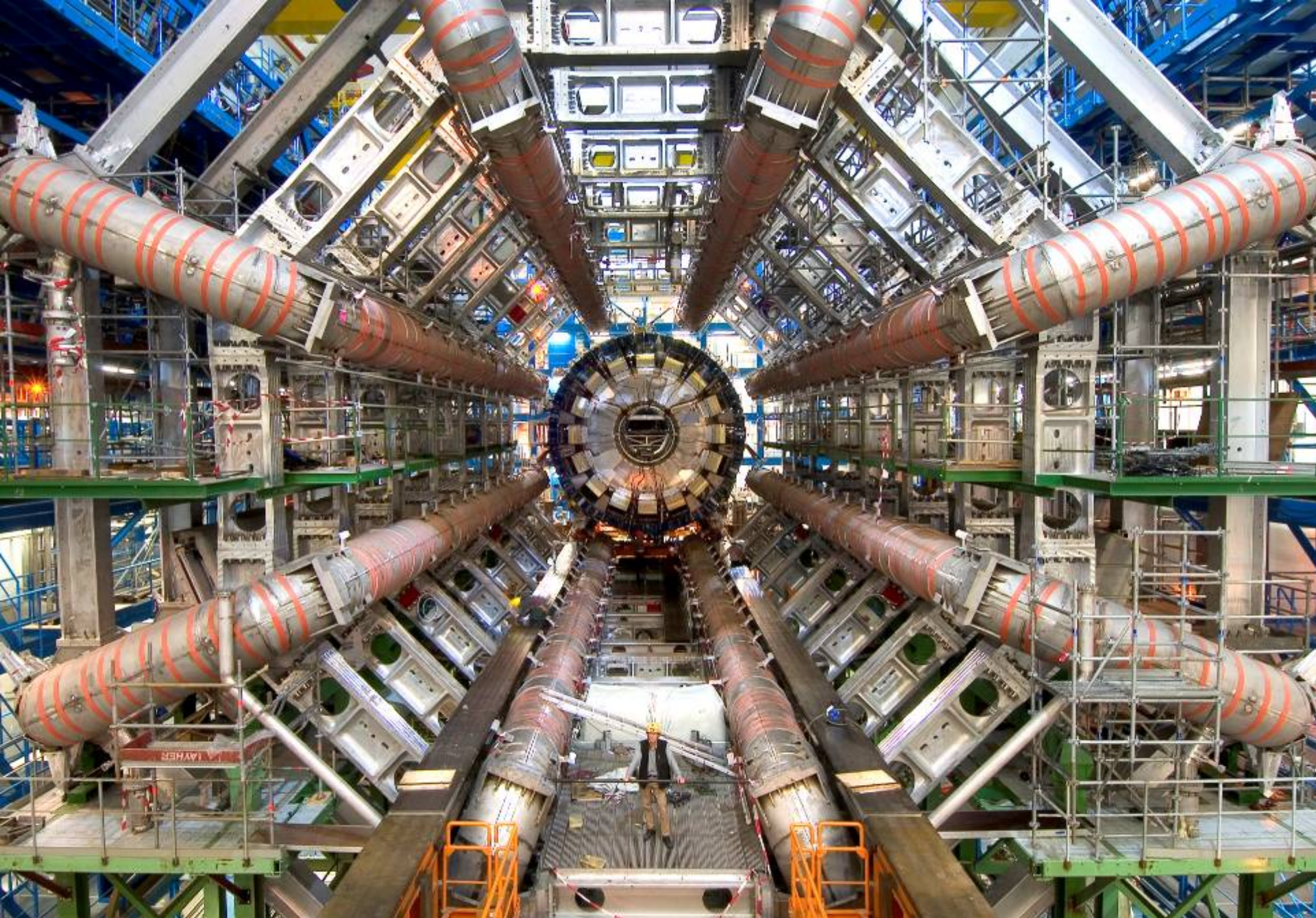


# The ATLAS Cavern



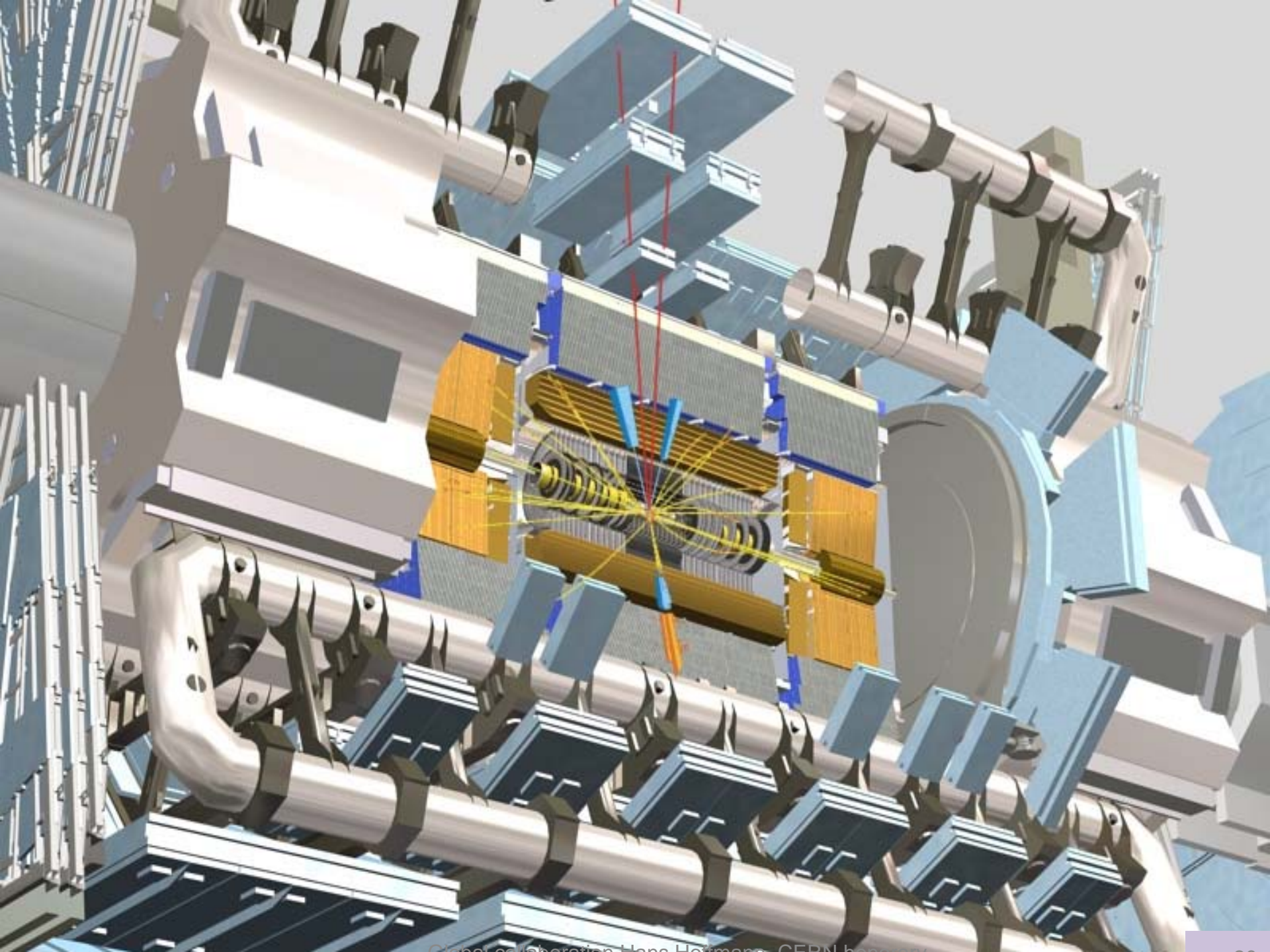




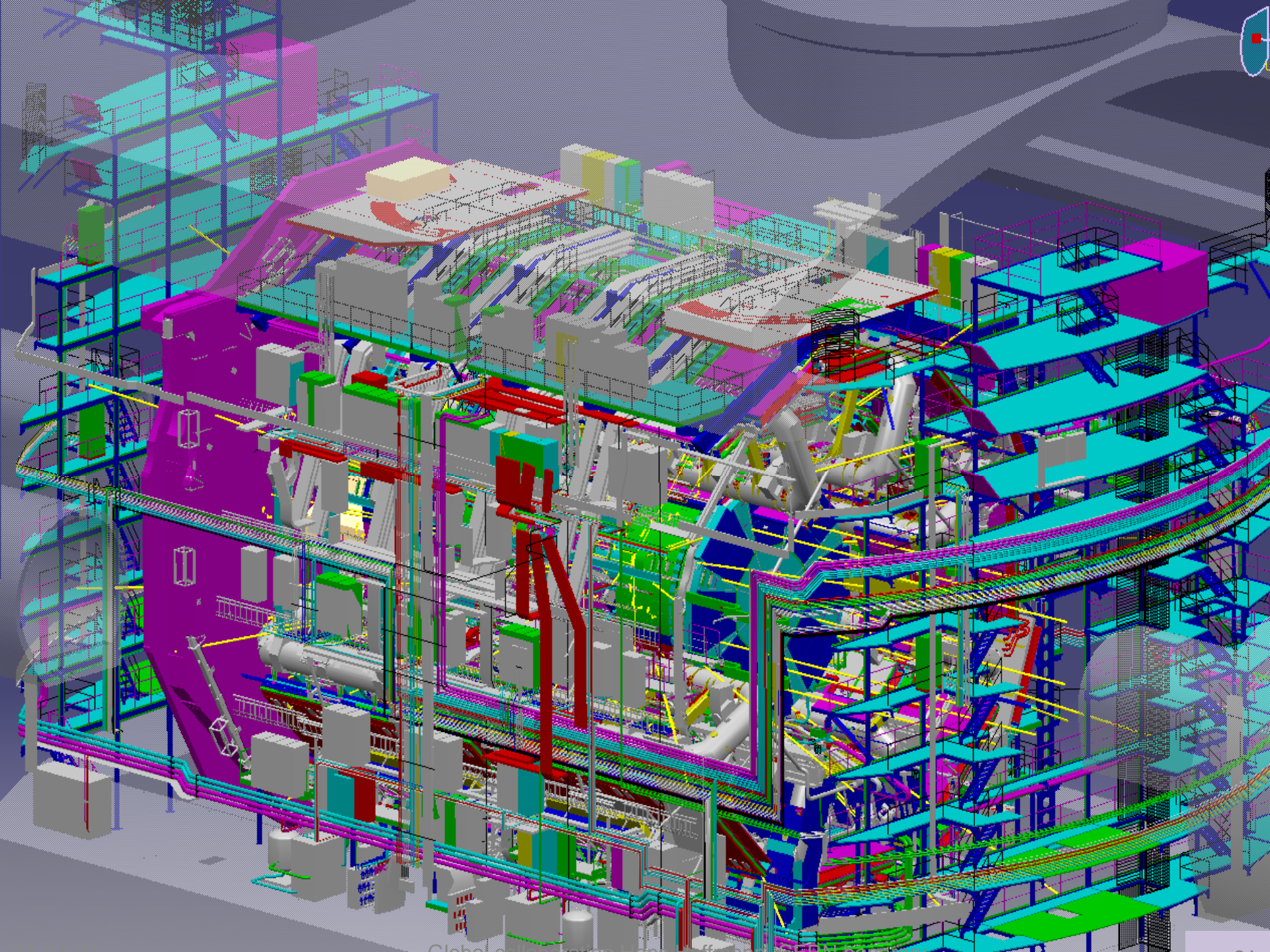


# The ATLAS Cavern











July 2008















"Digital camera", 150 M pixels, observing:  $10^9$  frames/s, recording selected frames: 200/s,  $\sim 1$  GB/s recorded volume







# Matter and elementary particles

## matter particles

	1st gen.	2nd gen.	3rd gen.
QUARK	 <i>u</i> up	 <i>c</i> charm	 <i>t</i> top
	 <i>d</i> down	 <i>s</i> strange	 <i>b</i> bottom
LEPTON	 <i>ν<sub>e</sub></i> <i>e neutrino</i>	 <i>ν<sub>μ</sub></i> <i>μ neutrino</i>	 <i>ν<sub>τ</sub></i> <i>τ neutrino</i>
	 <i>e</i> electron	 <i>μ</i> muon	 <i>τ</i> tau

## gauge particles

Strong Force  <i>g</i> Gluon x8
Electro-Magnetic Force  <i>γ</i> photon
Weak Force    <i>W</i> <sup>+</sup> <i>W</i> <sup>-</sup> <i>Z</i> <i>W bosons</i> <i>Z boson</i>

scalar particle(s)

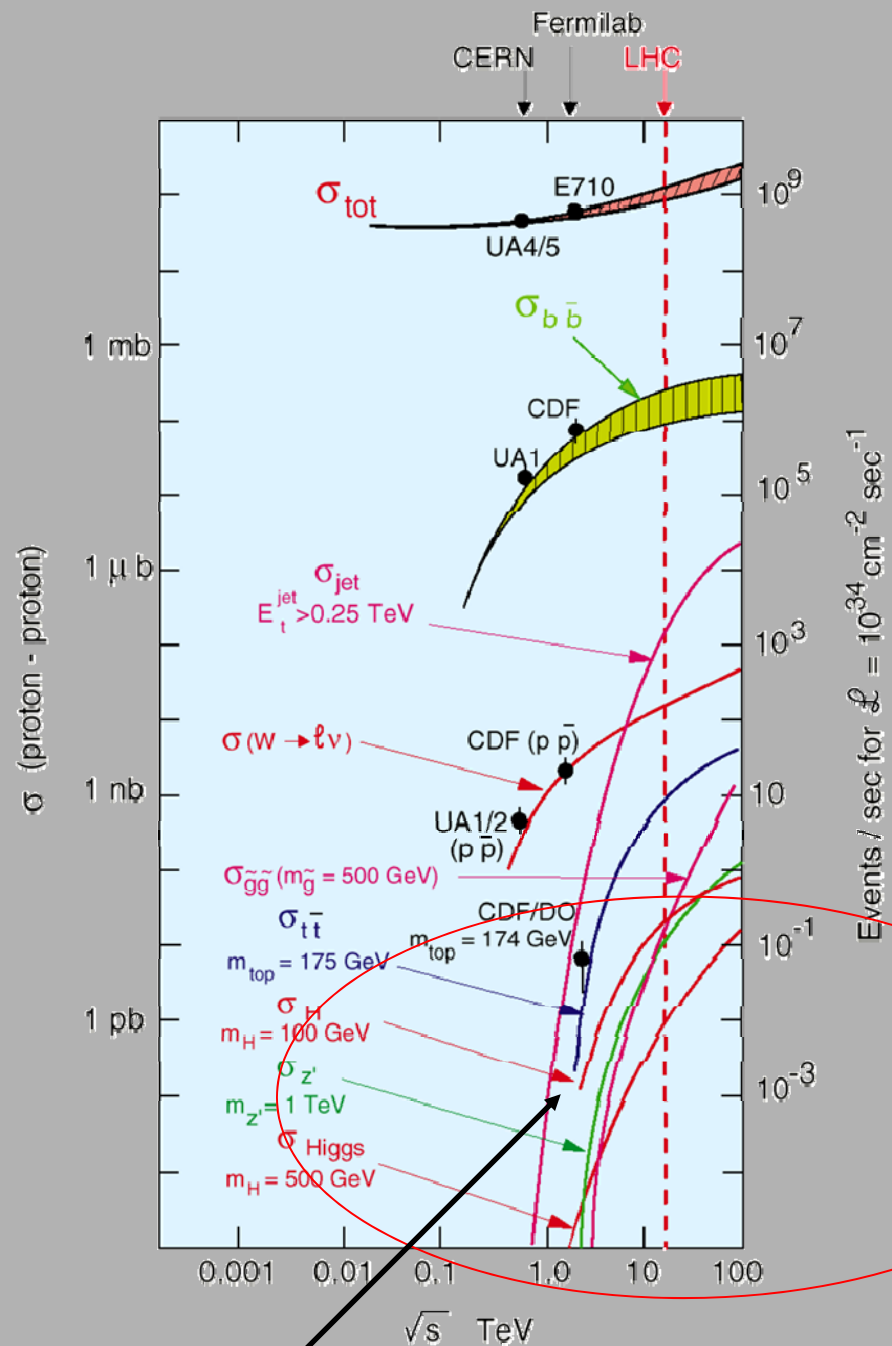


## Elements of the Standard Model

Masse « top »: 171 GeV; Masse « neutrino » < fraction eV:  
 $m_{\text{top}} / m_{\text{neutrino}} > 10^{13}$ ; explication par le champs de Higgs??



input information for  
experiments in 1988  
and following years  
plus  
technical know how

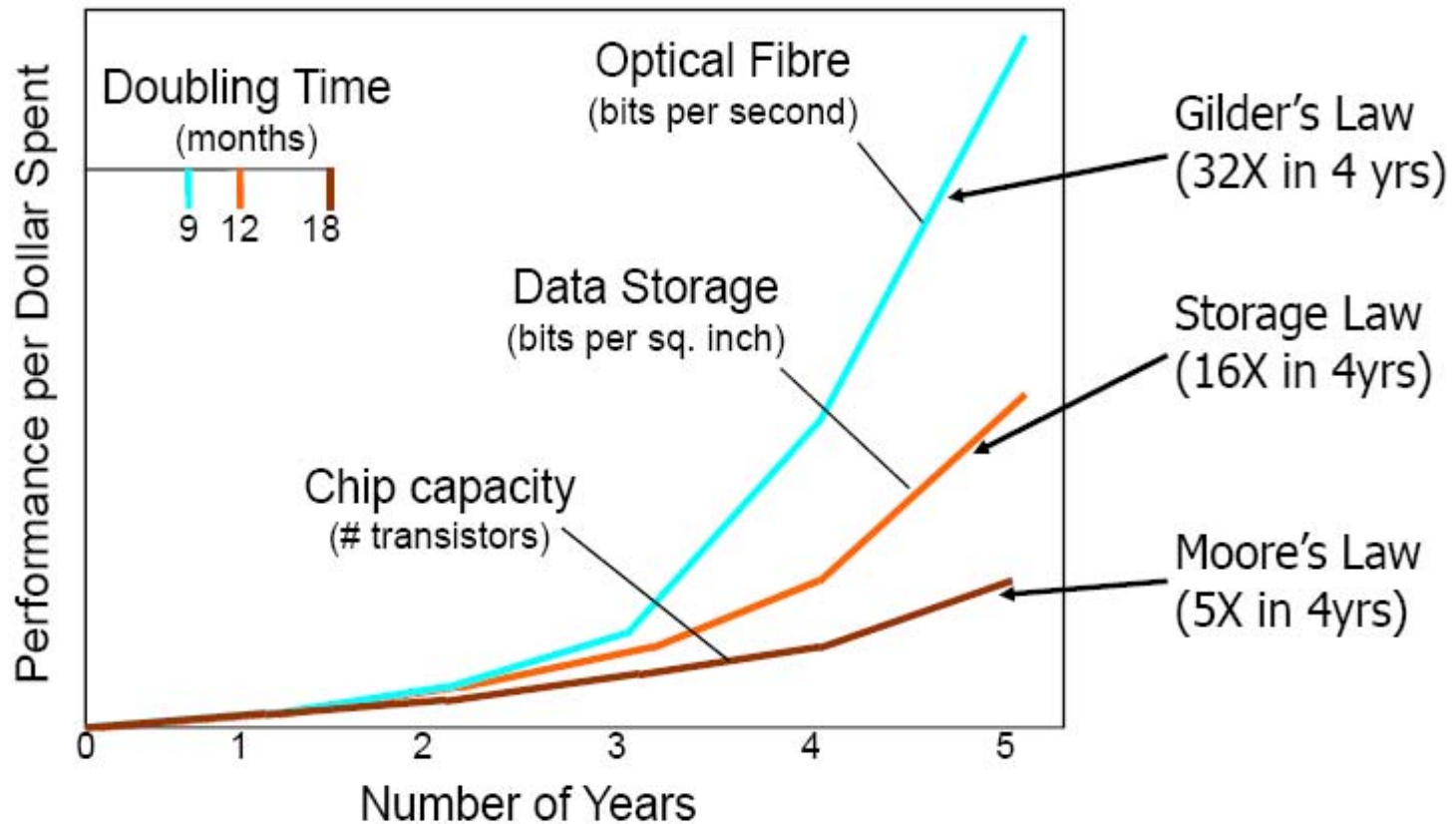


interesting physics



# Example: Technologies' watch

## Exponential Growth

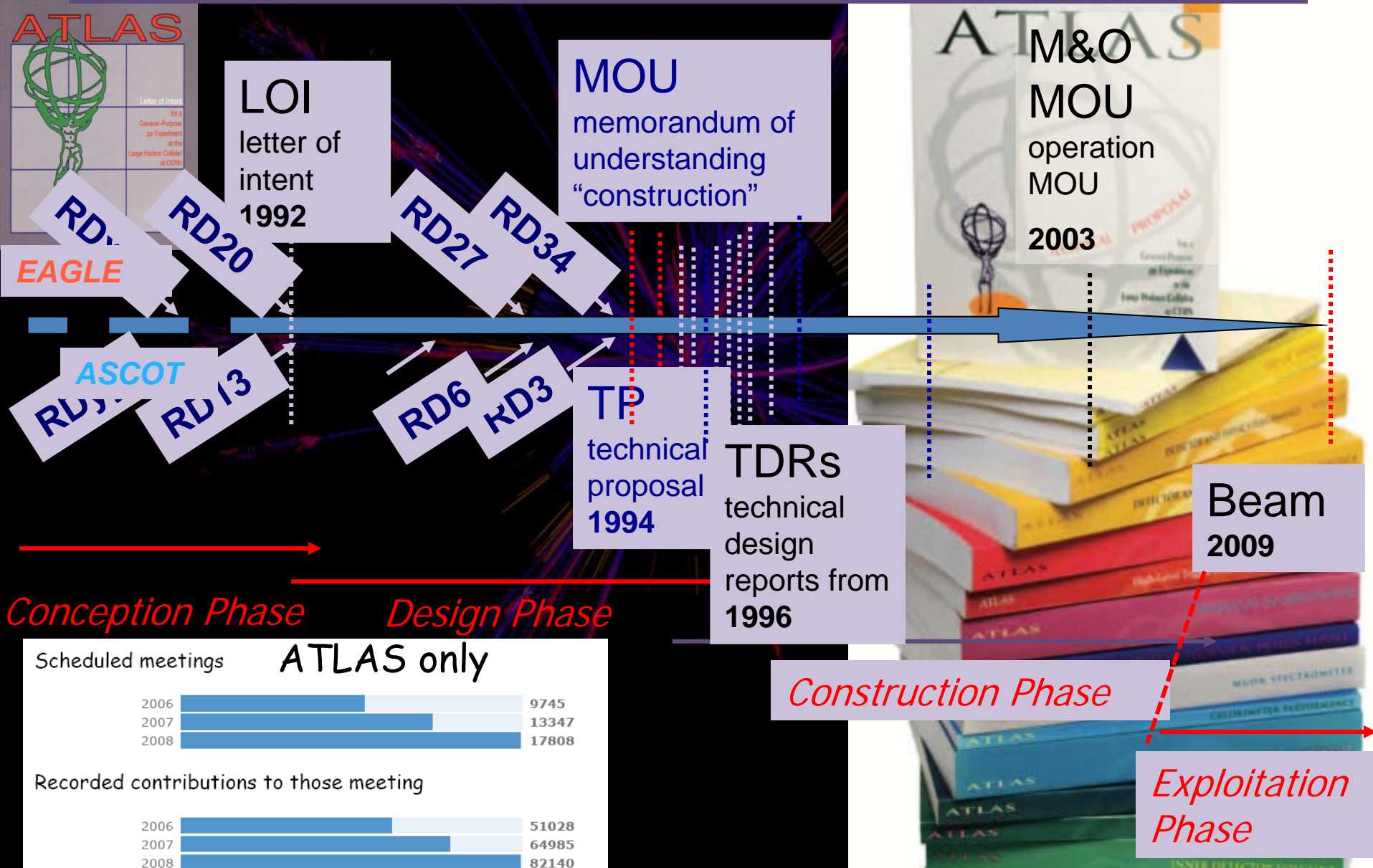


Triumph of Light – *Scientific American*. George Stix, January 2001



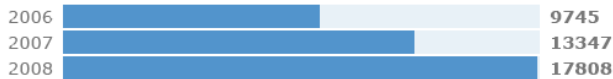


# Maximum use of everybody's knowledge



Scheduled meetings

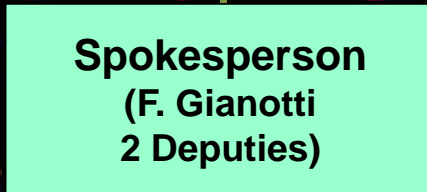
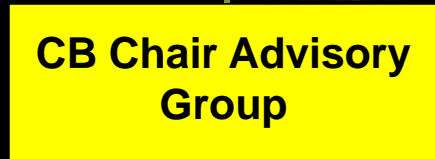
**ATLAS only**



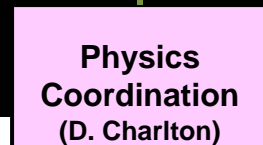
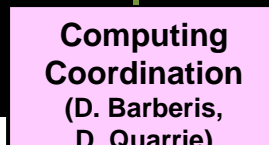
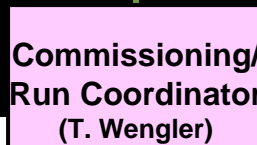
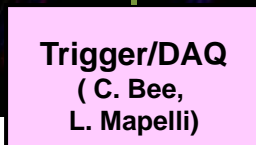
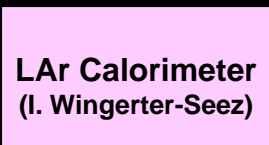
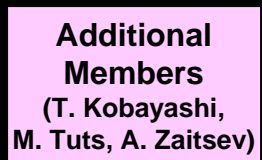
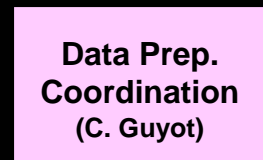
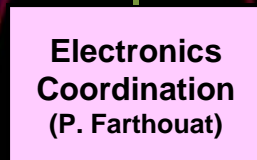
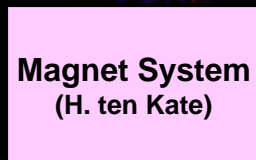
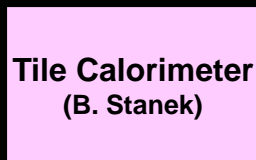
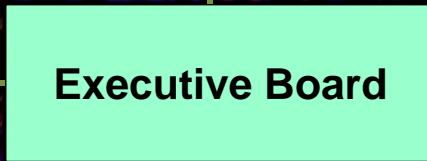
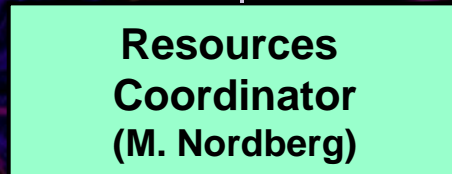
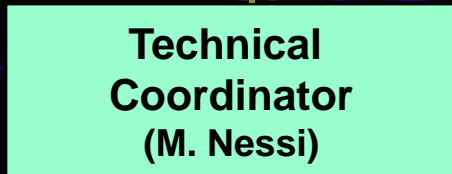
Recorded contributions to those meeting







*ATLAS Organization  
January 2009*





"Virtual" international big science laboratory  
Funded, supervised by ~50 funding agencies



*37 Countries*

*169 Institutions*

*2800 Scientific Authors*

*(1850 with a PhD)*

*1200 Technical persons*

*Thousands of industrial relations*

# ATLAS Collaboration



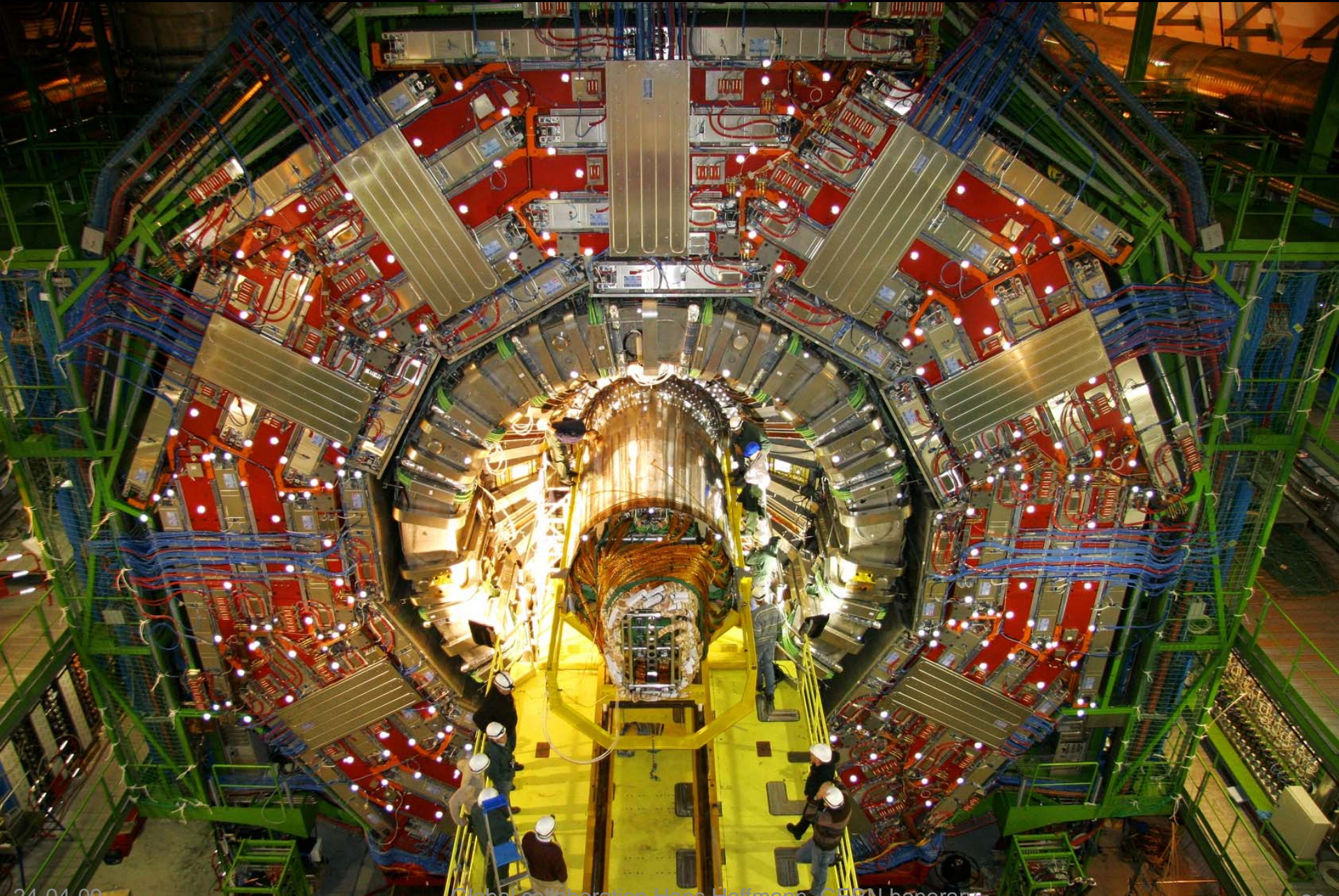


# International cooperation: Russian workers converting shells to CMS detector parts





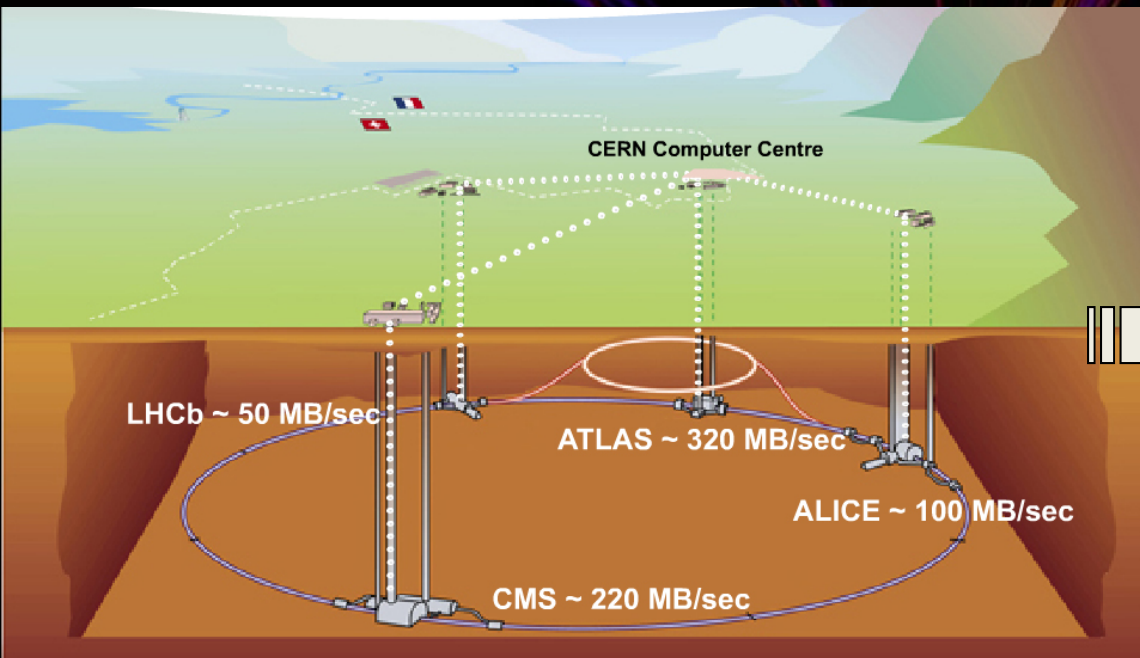
# CMS





# Computing for LHC

a GRID the size of the planet!



Every year, the LHC experiments will produce about 15 peta-bytes of data. This is more than a thousand times the information contained in all books the World over and around, ~ 1% of all data ever produced by mankind - including photographs, digital imagery and everything else you can imagine! The only suitable way of accessing such a large quantity of information is using grid technology.



# Information and Communication Technologies

ICTs are enabling, enhancing, encompassing, eliminating distances, **pervasive**, progressing rapidly

**Cannot do without ICTs: science, innovation, development, education, health, . . . :**

**overcome detail to address complexity**

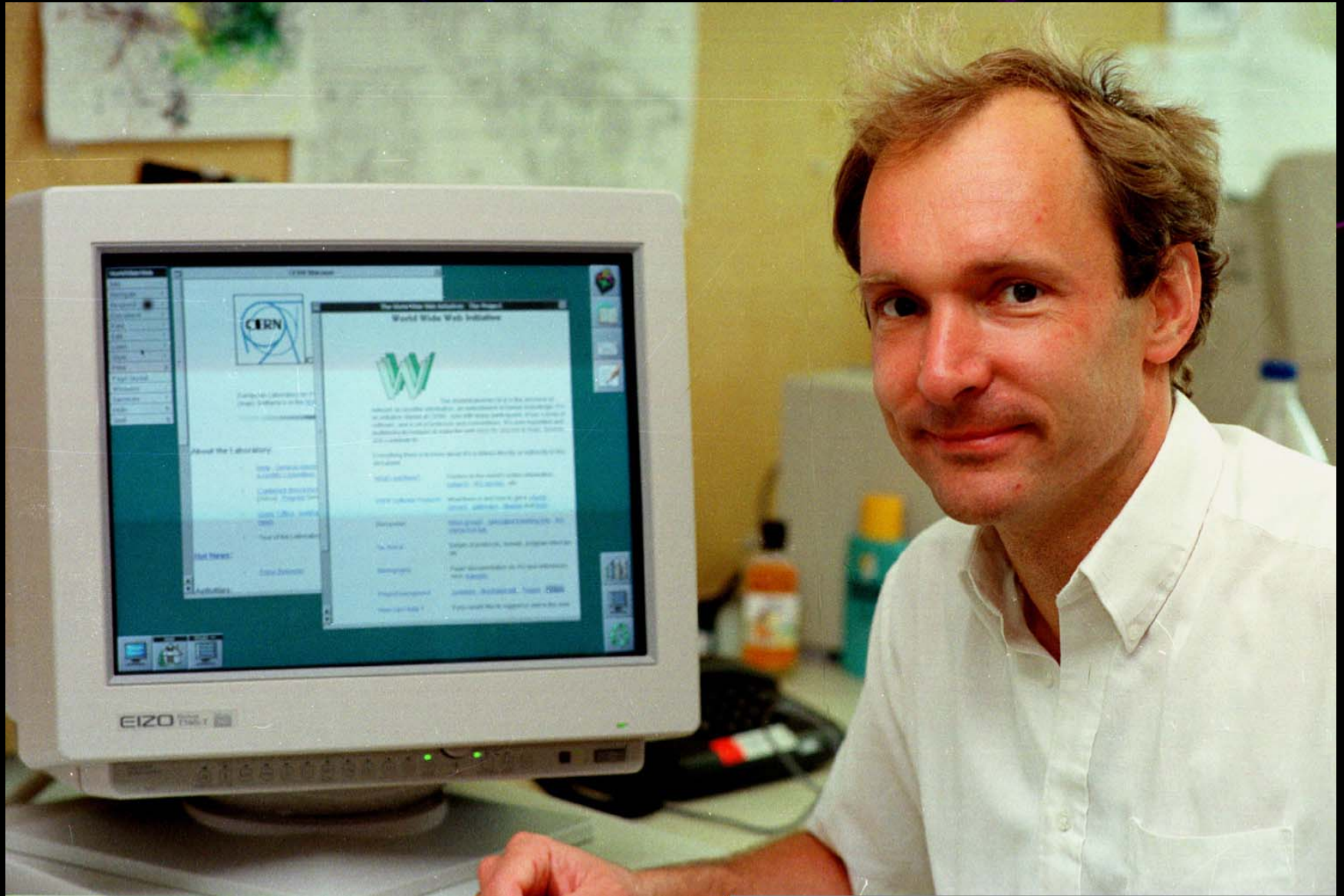
**need to get organised: collaborative culture, ICT education, application**

We report some experiences and messages from a computer literate, globally collaborating (e-) science: particle physics

Grids: dynamically link together resources as a whole to support the execution of novel, large-scale, resource-intensive, and distributed applications



# And have you heard of the... Web?



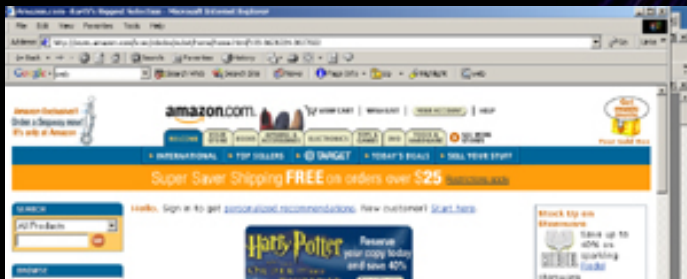




# What is the Grid?

The **World Wide Web** provides seamless access to information that is stored in many millions of different geographical locations

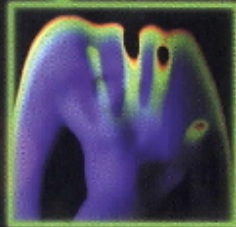
In contrast, the **Grid** is an emerging infrastructure that provides seamless access to computing power, software and data; distributed over the globe.







# Revolutionizing Science and Engineering through Cyberinfrastructure:



Report of the  
National Science Foundation  
Advisory Panel on  
Cyberinfrastructure

February 3, 2003



# Creating virtual organisations

**Access to them needs to be provided in a secure, coordinated, seamless, dynamic and inexpensive way**

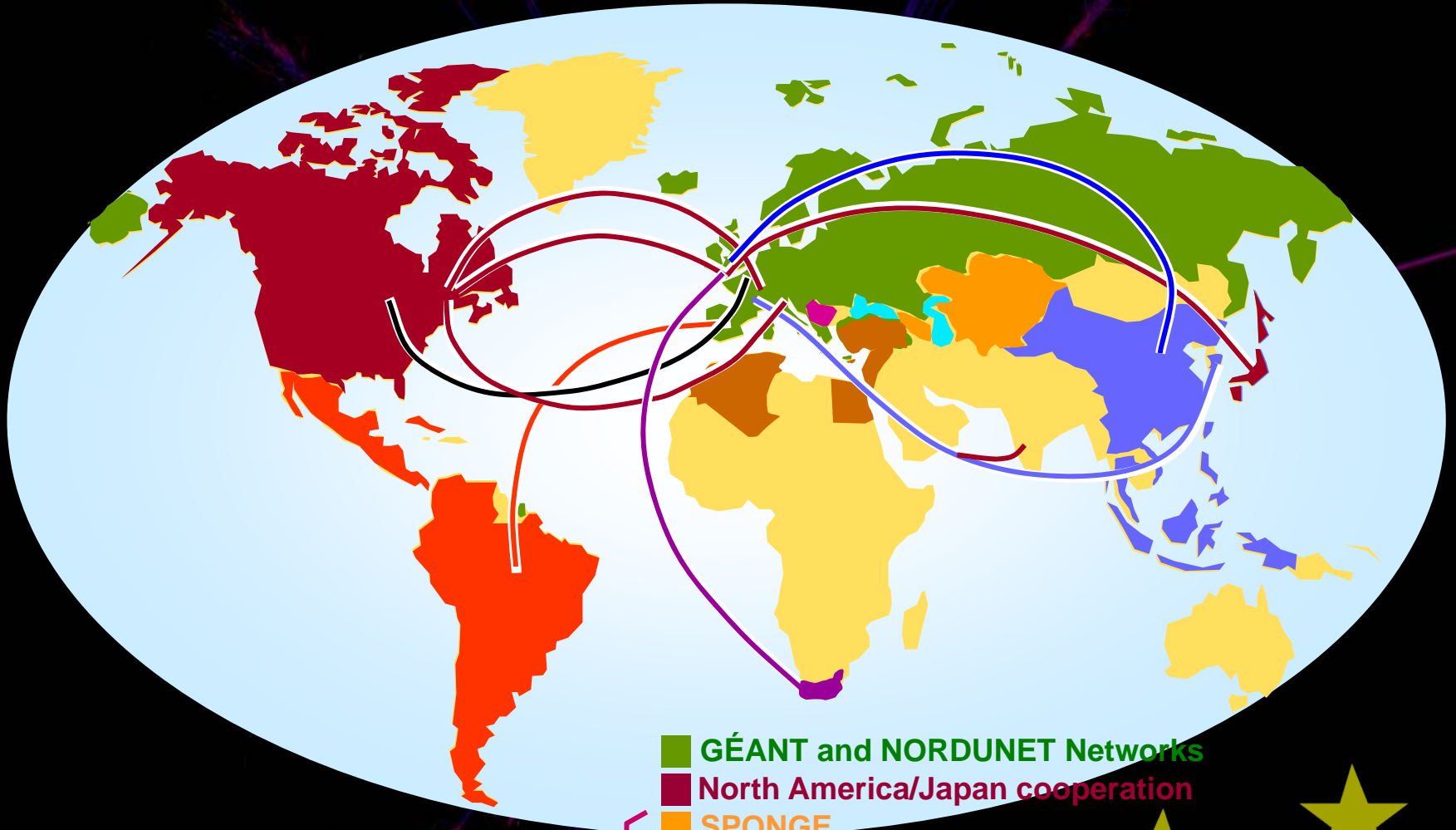


- Resources can be physical, virtual, single or multiple sited
- Resources can be distributed world-wide
- Resources can be of any information type (storage, library, computing, networking, instrumentation, etc)





# GÉANT - the global dimension



- GÉANT and NORDUNET Networks
- North America/Japan cooperation
- SPONGE
- SEEREN
- EUMEDCONNECT
- ALICE
- TEIN2
- S. Africa
- China
- India

Budget - 32 M€

In 2006

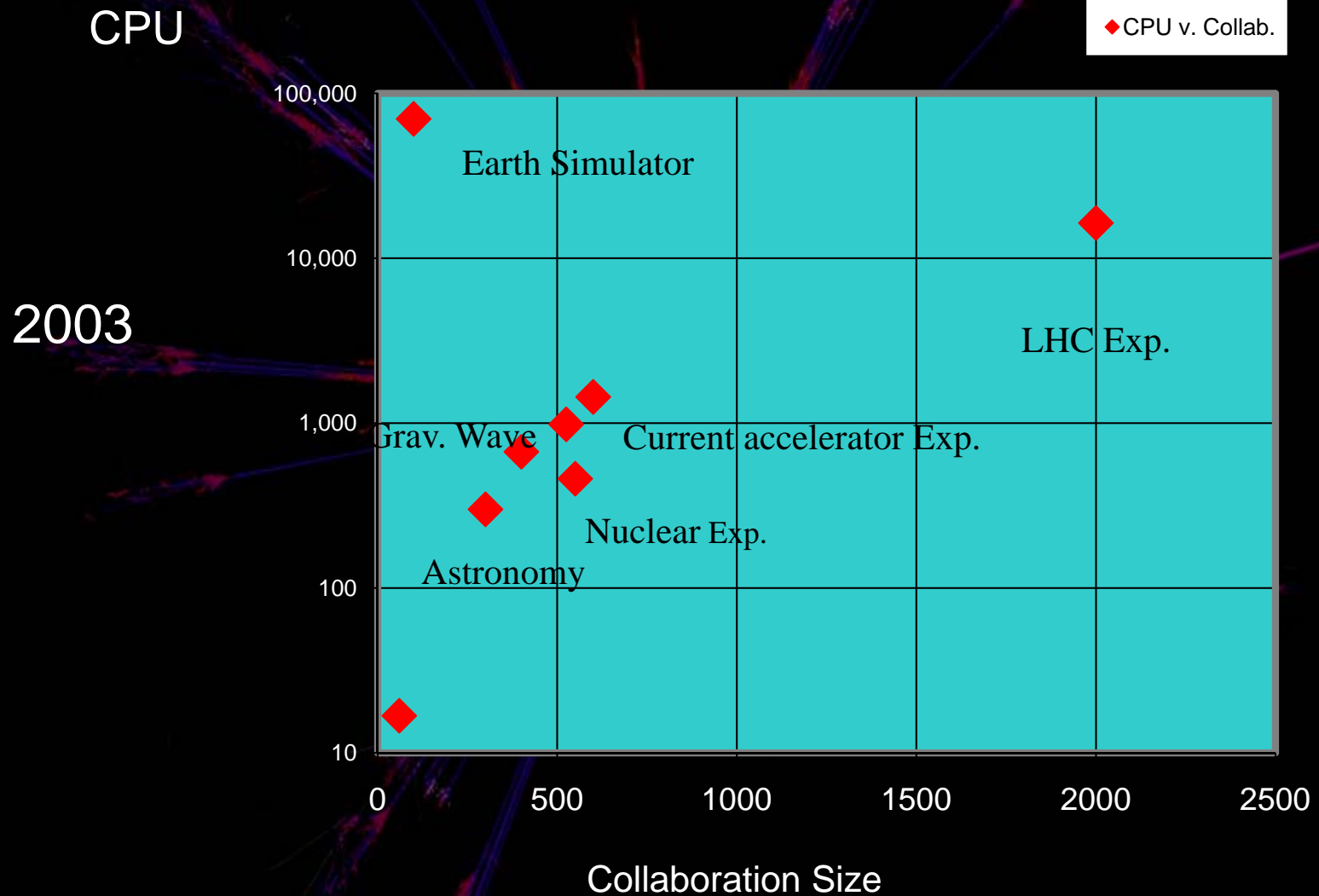
European Commission  
Information Society and Media

Mário Campolargo, DG INFSO



# Measure Science Information Utility-Infrastructure

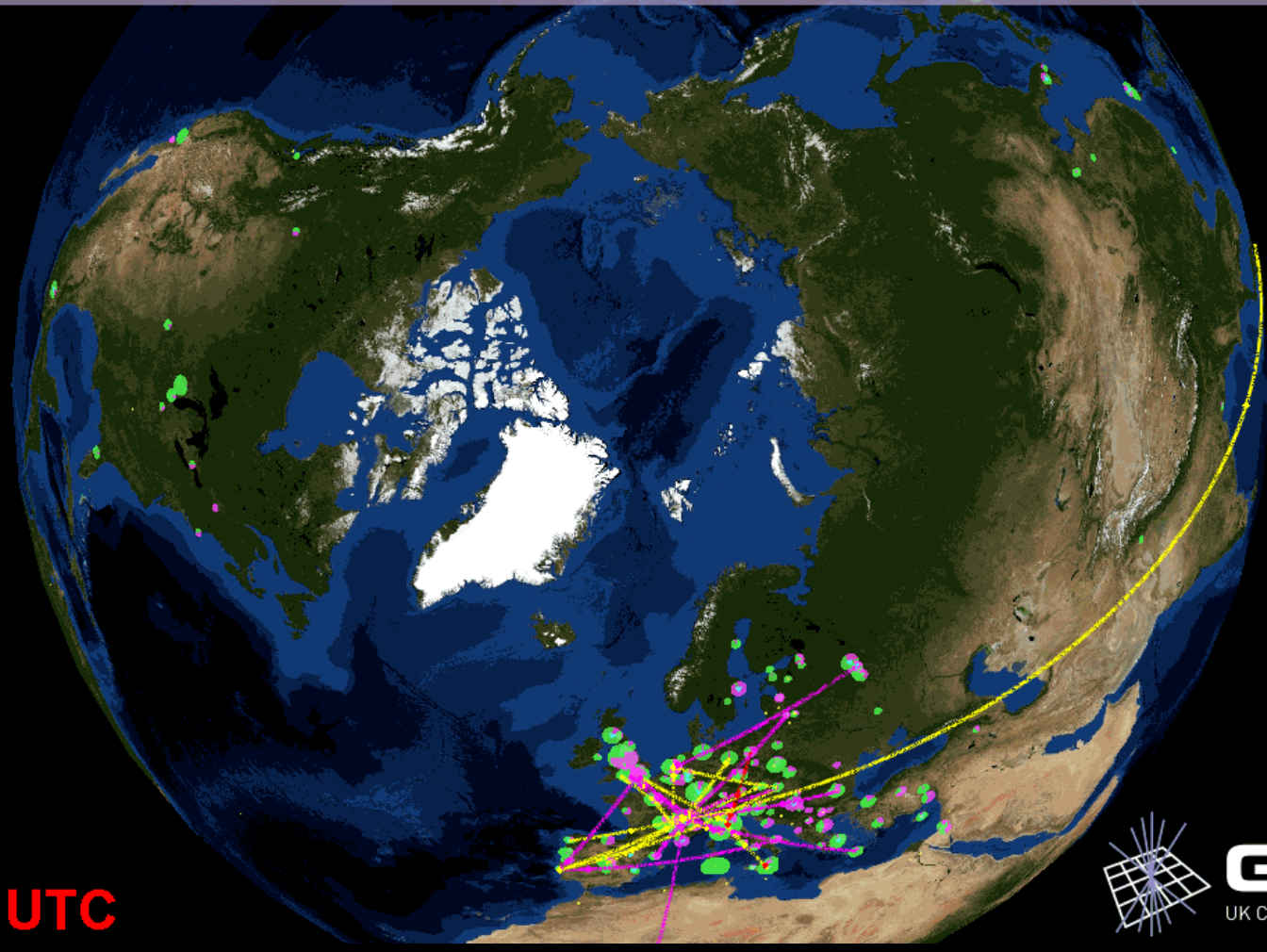
## CPU v. Collab.





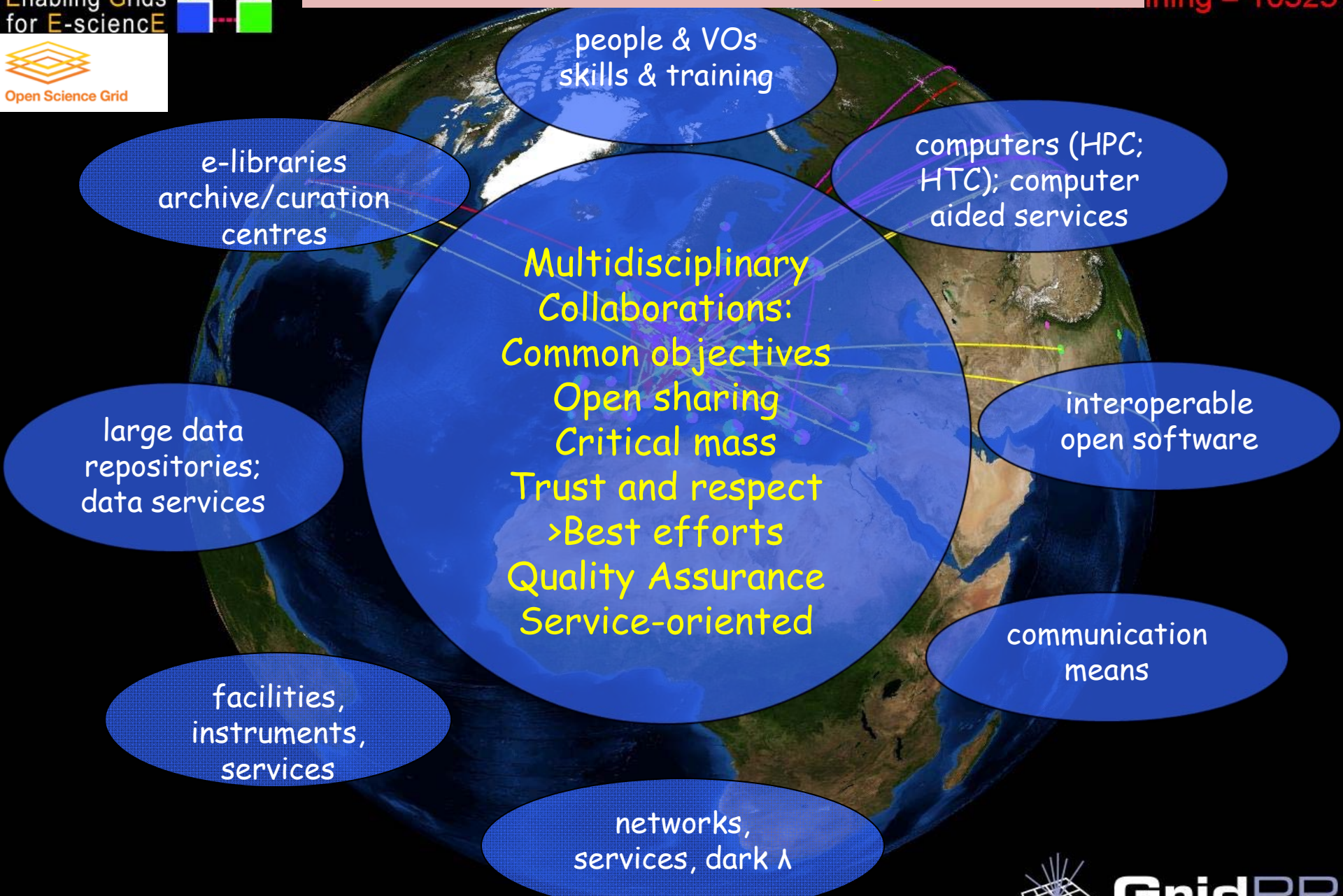
Provide equal access to the data, software,  
compute power. . to all participating scientists

Grids = 21539  
Running = 25374

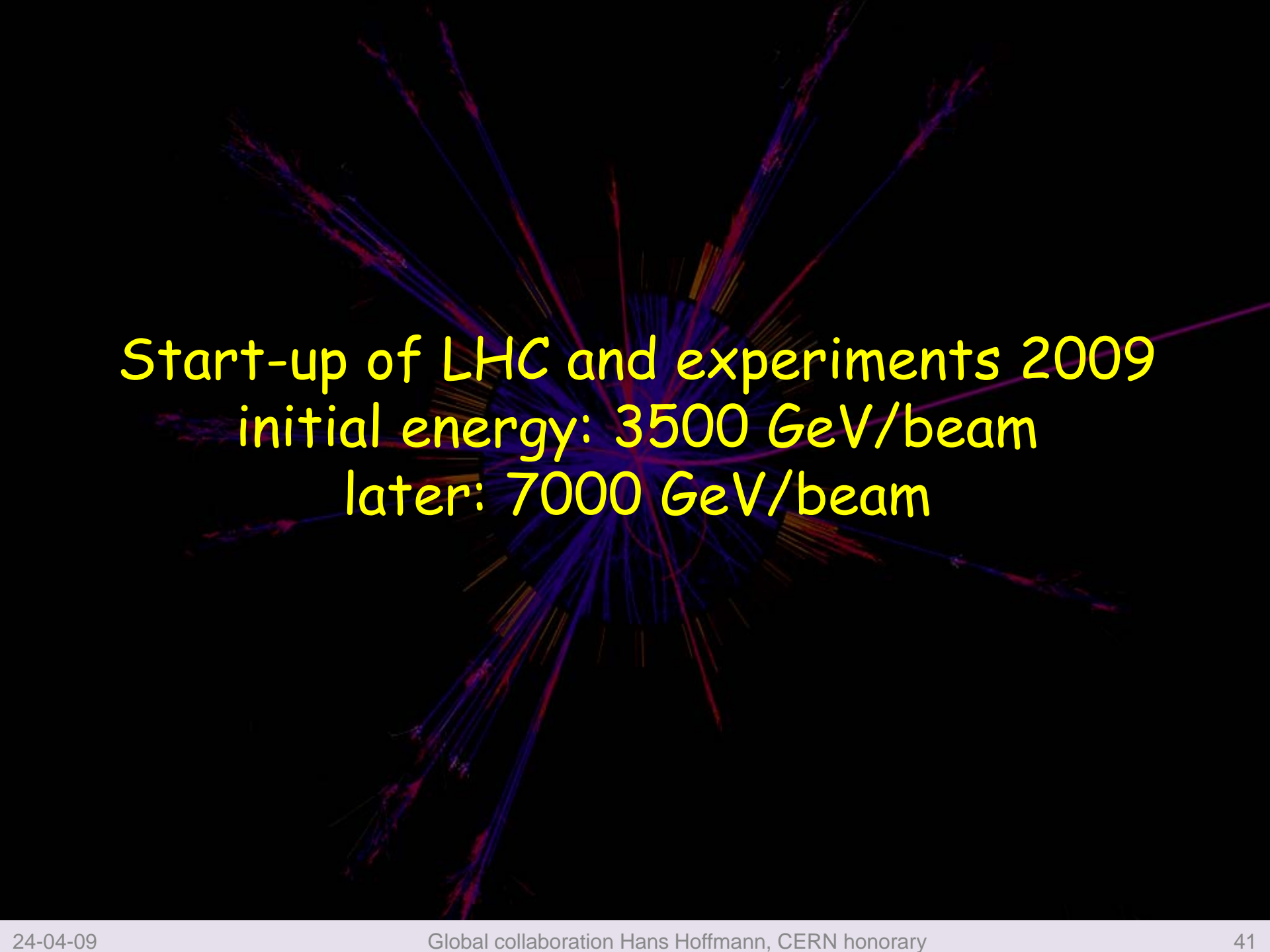


21:13:50 UTC

*"e-Science is about more than networks, Grids, High Performance Computing...; e-science is about global collaboration in key areas of science and the next generation of infrastructure that will enable it."* John Taylor, Director Research Councils, UK, 2000





A visualization of particle tracks, likely from a particle detector, showing a central point from which numerous tracks radiate outwards. The tracks are colored in shades of blue, purple, and red, and appear to be composed of many small segments. The background is black.

Start-up of LHC and experiments 2009  
initial energy: 3500 GeV/beam  
later: 7000 GeV/beam

# CERN as an Educator



Apprentices

Accelerator School

Doctoral Students

Academic Training

Fellows

Physics School

Exhibitions

CERN-Latin America School

Computing School

Visits

Summer Students

Technical Students

Outreach

Science on Stage

Microcosm

Technical Training

Teachers programmes

Language Training

Conferences

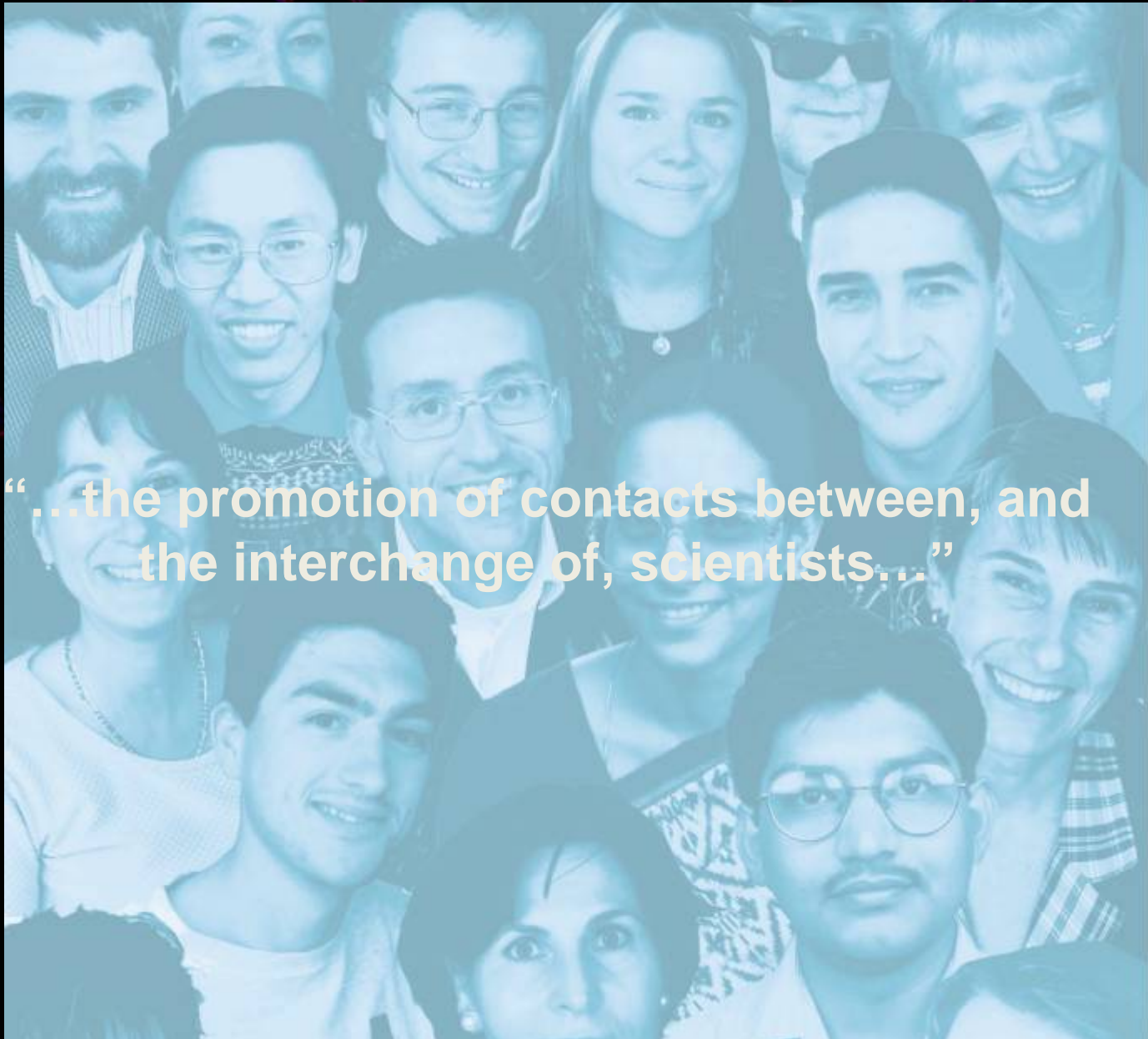
e-library school

Communications Training

Management Training



# Bringing Nations Together



“...the promotion of contacts between, and the interchange of, scientists...”

# Knowledge preservation and availability (CERN)

Technical and scientific knowledge: publish and share "Open Access"; "green" ~100% , "gold" >85% publications

Proprietary, industrial information: observe industrial agreements

Data: private to collaboration until no further interest, but publish any findings immediately (compete with other expts.)

To work meaningfully with data one needs details of calibration, simulation, software, ... and their time development

Finally produce and **publish combined data analysis** of all LHC experiments and their interesting physics channels



# Green and golden roads to Open Access publications

>20'000 journals, 2-3million articles/y; not affordable for anybody → OA  
Access, affordability and impact: **OA on the web addresses all**

## Green Road to OA:

Institutes mandate authors to self-archive all published articles in  
the institutional repository

## Golden road:

mandate authors to publish in Open Access journals; authors pay  
for publications; publication fees part of research grant or in  
charge of mandating institution(s); authors keep copyright

Use common-use licenses, with "some rights reserved" i.e. creative  
commons public licenses

Promote Open Access to educational content and data

Work on making use of the full potential of the digital medium and put an  
OA repository into each University or one for all

Promote e-/cyber infrastructures for open, collaborative, networked  
science

# IP, copyright, public interest

Broad implications of excessive restrictions on access to and reuse of government and government-funded research data

- Higher research costs

- Significant lost opportunity costs

- Barriers to innovation

- Less effective cooperation, education, and training

- Developing countries especially disadvantaged

Can avoid hyper-protection of data and information, especially in the public sector, by

- Balancing IP laws between the rights holder interests and the public interest, consistent with the country's level of development

- Carve out broad public-interest exceptions for the public sector

- Use common-use licenses (example "creative commons")

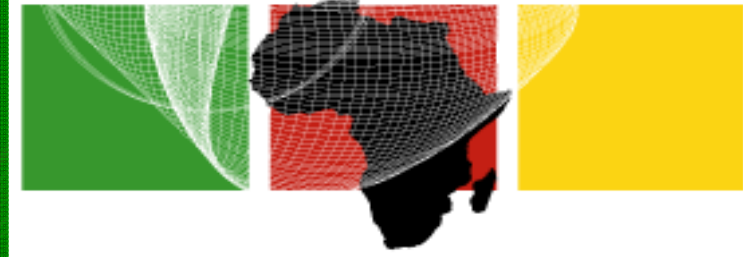




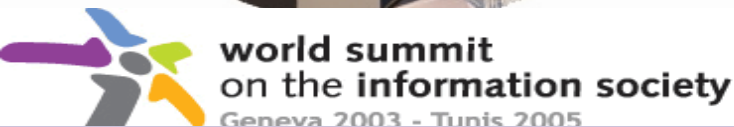
# the **role of science** in the **information society**

CERN, Geneva, 8-9 December 2003

International Workshop on  
African Research & Education Networking  
September 25-27 2005  
ITU, UNU and CERN for WSIS II in Tunis



Results:  
**Education, Training and Knowledge  
are Keys to Development**  
ICT are the means of storage of  
local content and access to the  
knowledge of the world; ICT make  
us virtual neighbours and enable  
close collaborations of distant  
partners using grids and e-  
infrastructures





# Introduce e- repositories/libraries to African Universities to make African research output visible in the world

Training in hard- and software for librarians from I-Themba/ZA, AAU Ghana, Rwanda (Kigali Inst. Education), Madagascar with the help of UNESCO IBSP in winter 2007

e-Library tutoring and training for ~30 librarians from 15 institutions in Rwanda/Kigali in autumn 2009

Training courses for high school teachers in physics, provision of teaching content





The global community of particle physicists  
and CERN...

Seeking answers to questions about the Universe

Advancing the frontiers of technology

Training the scientists, entrepreneurs, teachers of  
tomorrow

Bringing nations together through science



Knowledge is the capacity to act, the potential to start something\*

The value of knowledge increases with its use

(Fundamental) scientific knowledge must be freely available (WSIS I: scientific community), "5<sup>th</sup> freedom" or "free movement of knowledge" for publicly funded research

When addressing great challenges, obtaining, sharing of all relevant knowledge is indispensable

Balance IP laws between the rights holder's interests and the public interest, consistent with the country's level of development