



# Accelerating Science and Innovation



## Welkom Nederlanders @ CERN

Herman ten Kate

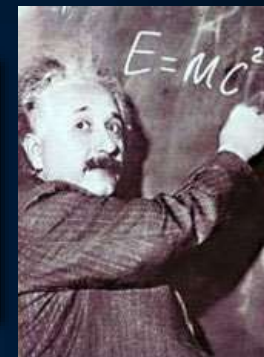
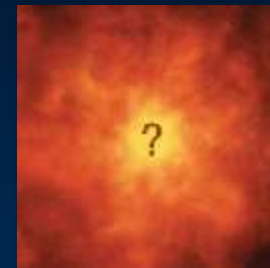




# The Mission of CERN

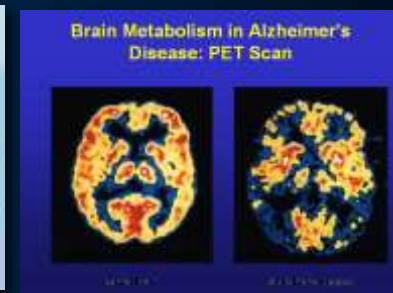
- ❑ **Push forward** the frontiers of knowledge

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, accelerators and detectors

Information technology  
Medicine - diagnosis and therapy



- ❑ **Train** scientists and engineers of tomorrow



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



# CERN was founded 1954: 12 European States

“Science for Peace”

## Today: 21 Member States

~ 2300 staff

~ 1300 other paid personnel

> 11500 users

Budget (2015) ~1000 MCHF

NL contribution ~4.5% (43 M€)

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

**States in accession to Membership:** Romania, Serbia

**Applications for Membership or Associate Membership:**

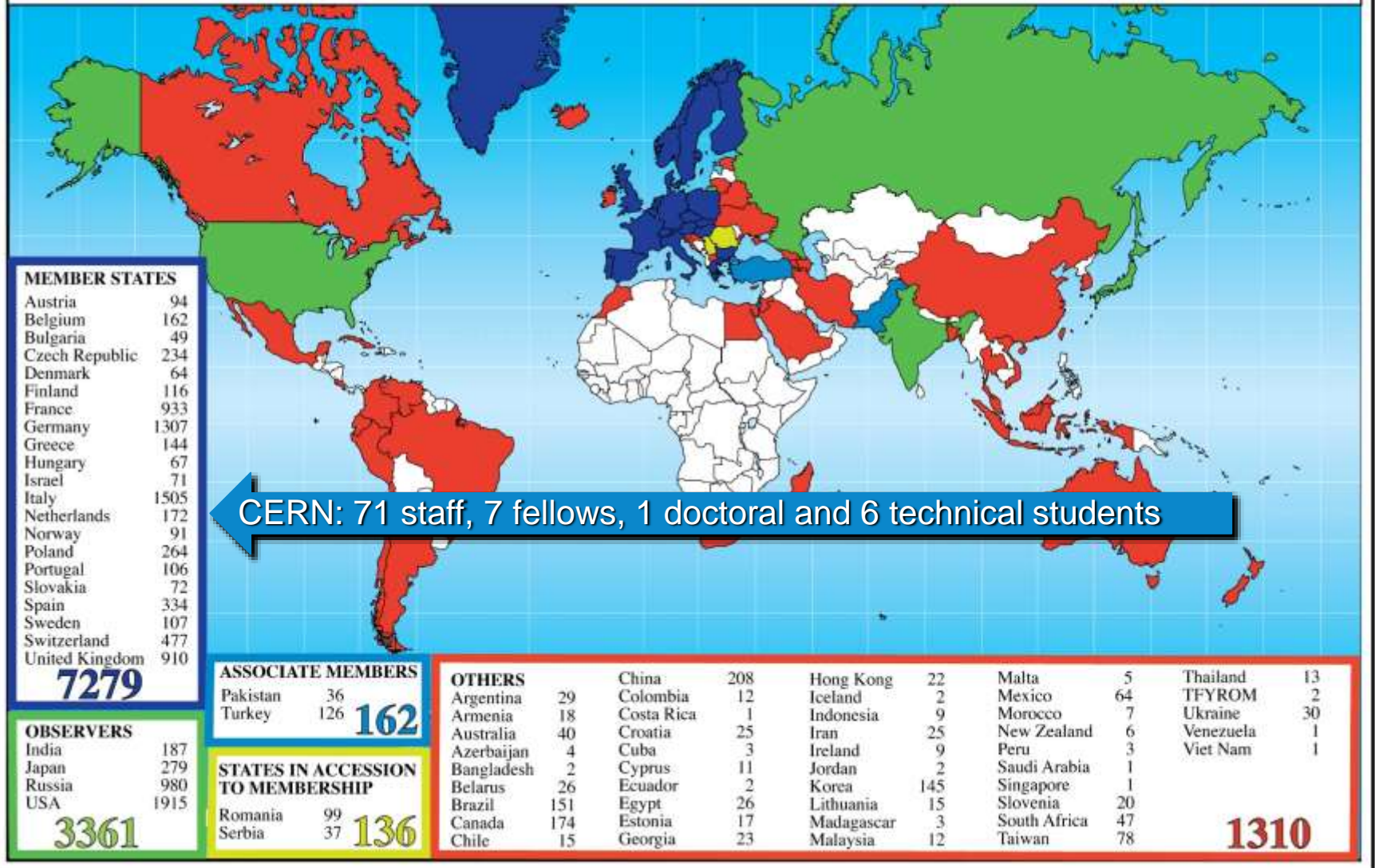
Brazil, Croatia, Cyprus, Pakistan, Russia, Slovenia, Turkey, Ukraine

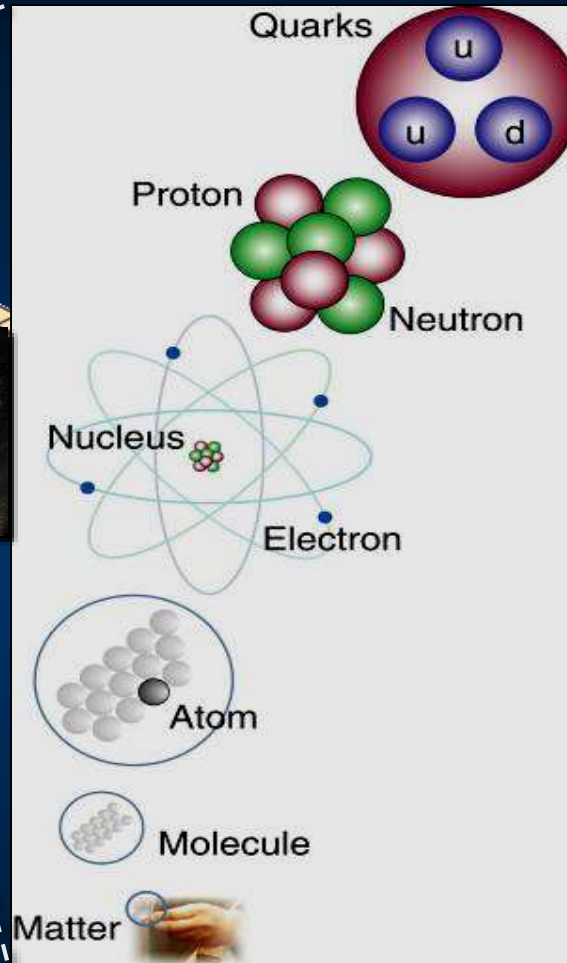
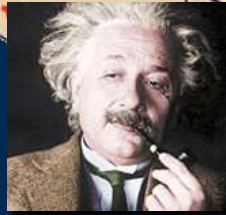
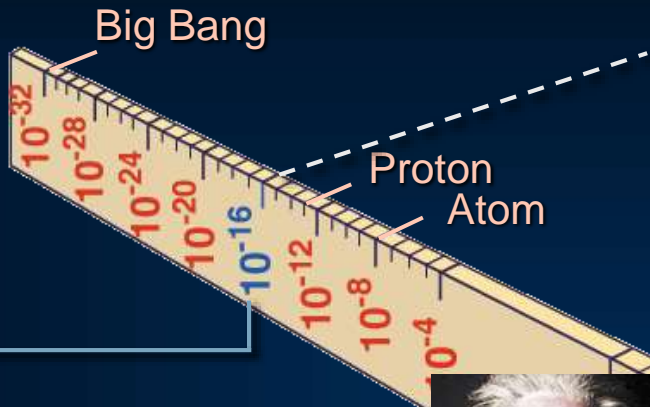
**Observers to Council:** India, Japan, Russia, Turkey, United States of America; European Union, JINR and UNESCO



# Science is getting more and more global

Distribution of All CERN Users by Location of Institute on 12 January 2016





LHC

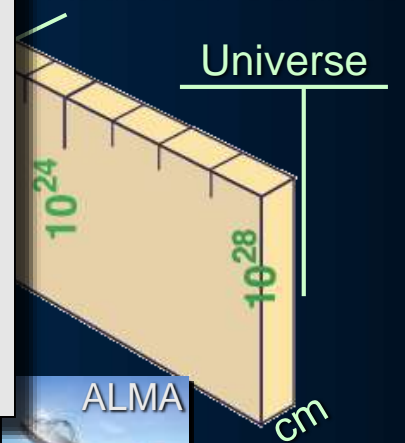
Super-Microscope



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

Radius of Galaxies

Universe

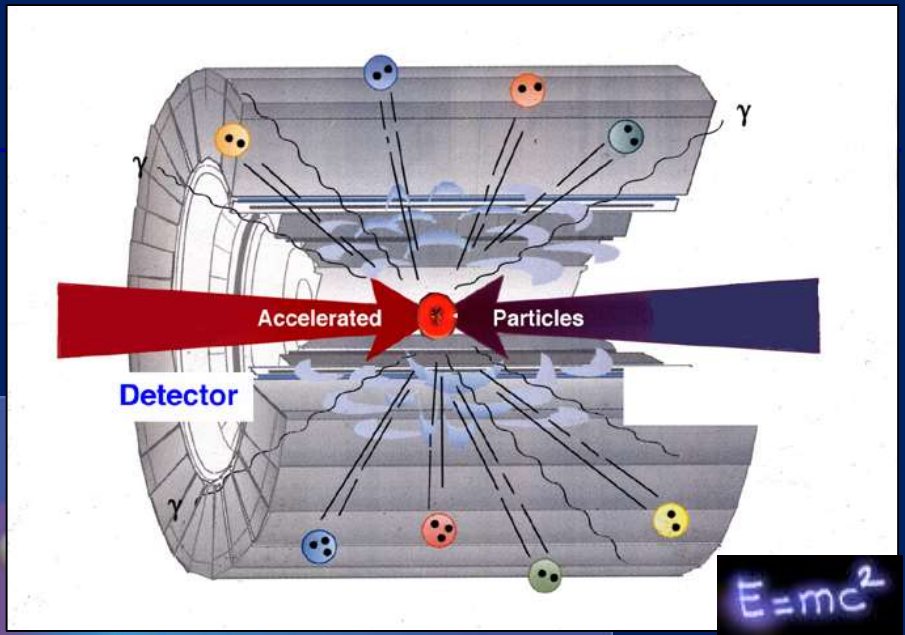




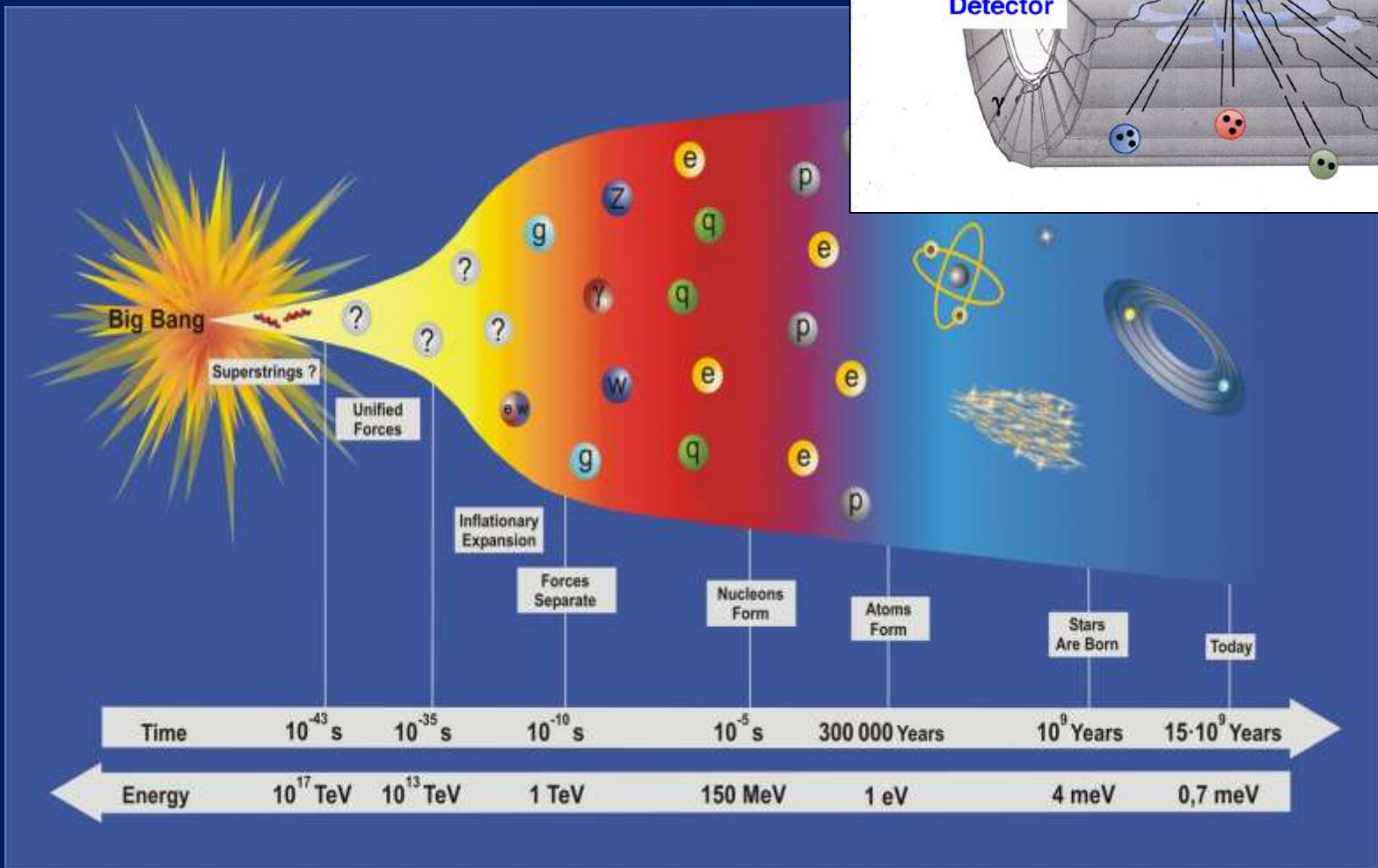


$$E = mc^2$$

Generation of heavy particles with short life time

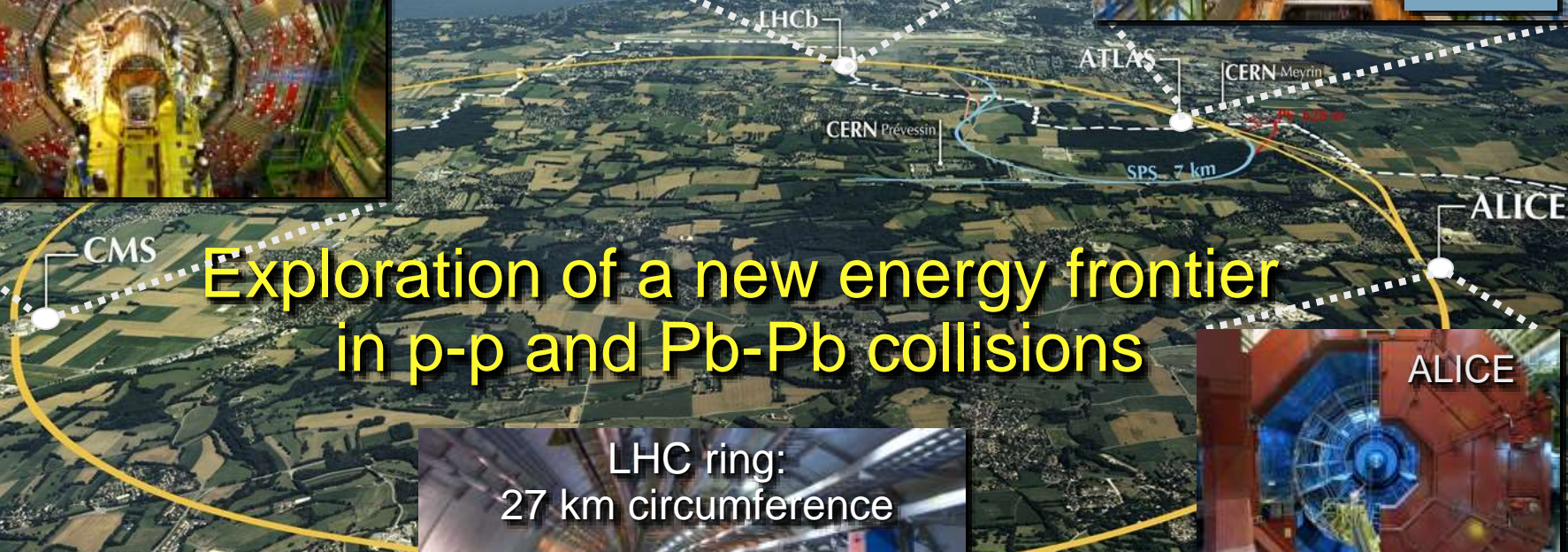


$$E = mc^2$$





# Entering a New Era in HEF Science.....



Exploration of a new energy frontier  
in p-p and Pb-Pb collisions







# ATLAS on surface and underground

- Underground cavern at - 90 m
- 2 shafts give access to a 50,000 m<sup>3</sup> cavern for the detector



Cavern length = 55 m  
width = 32 m  
height = 35 m

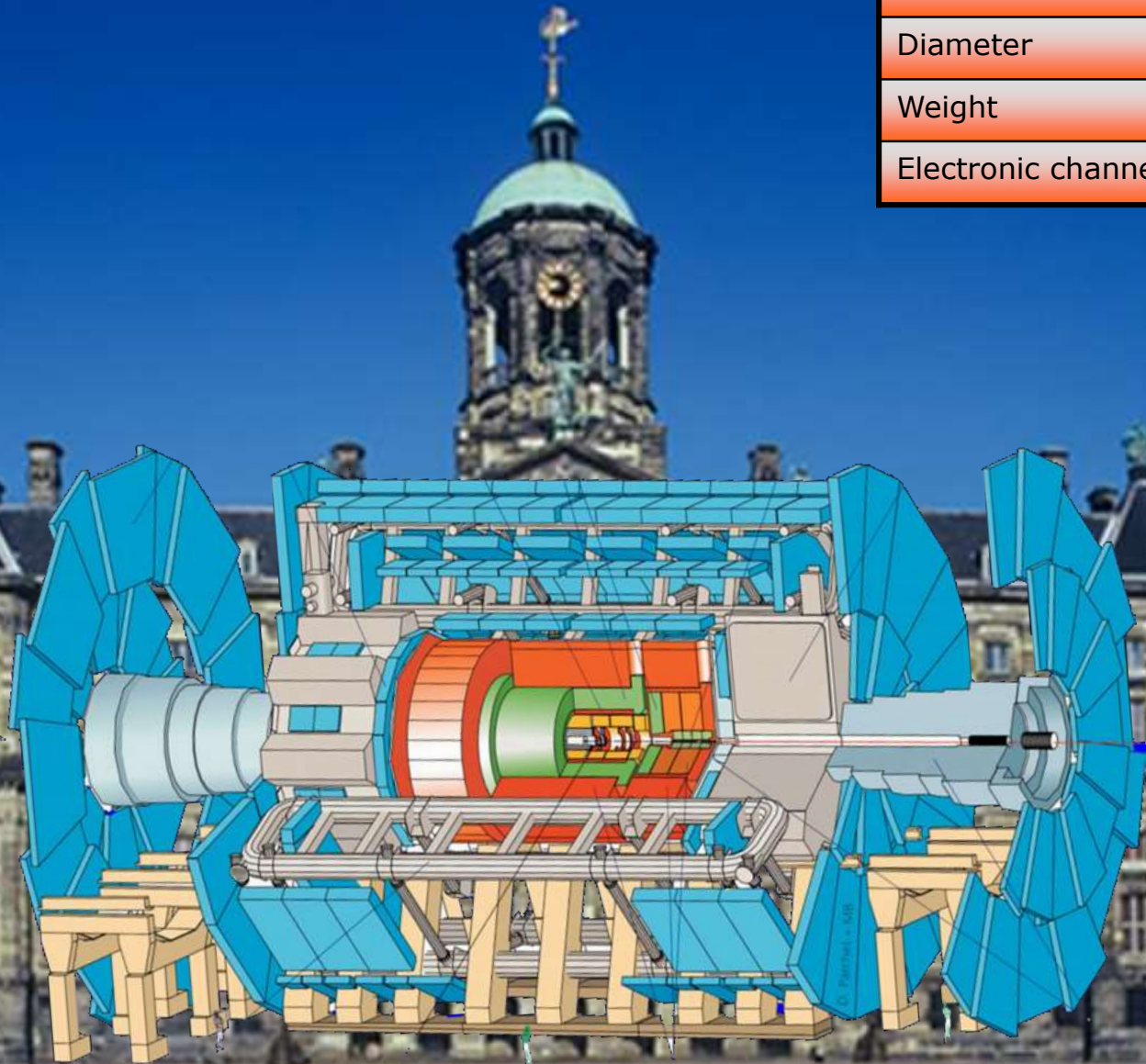




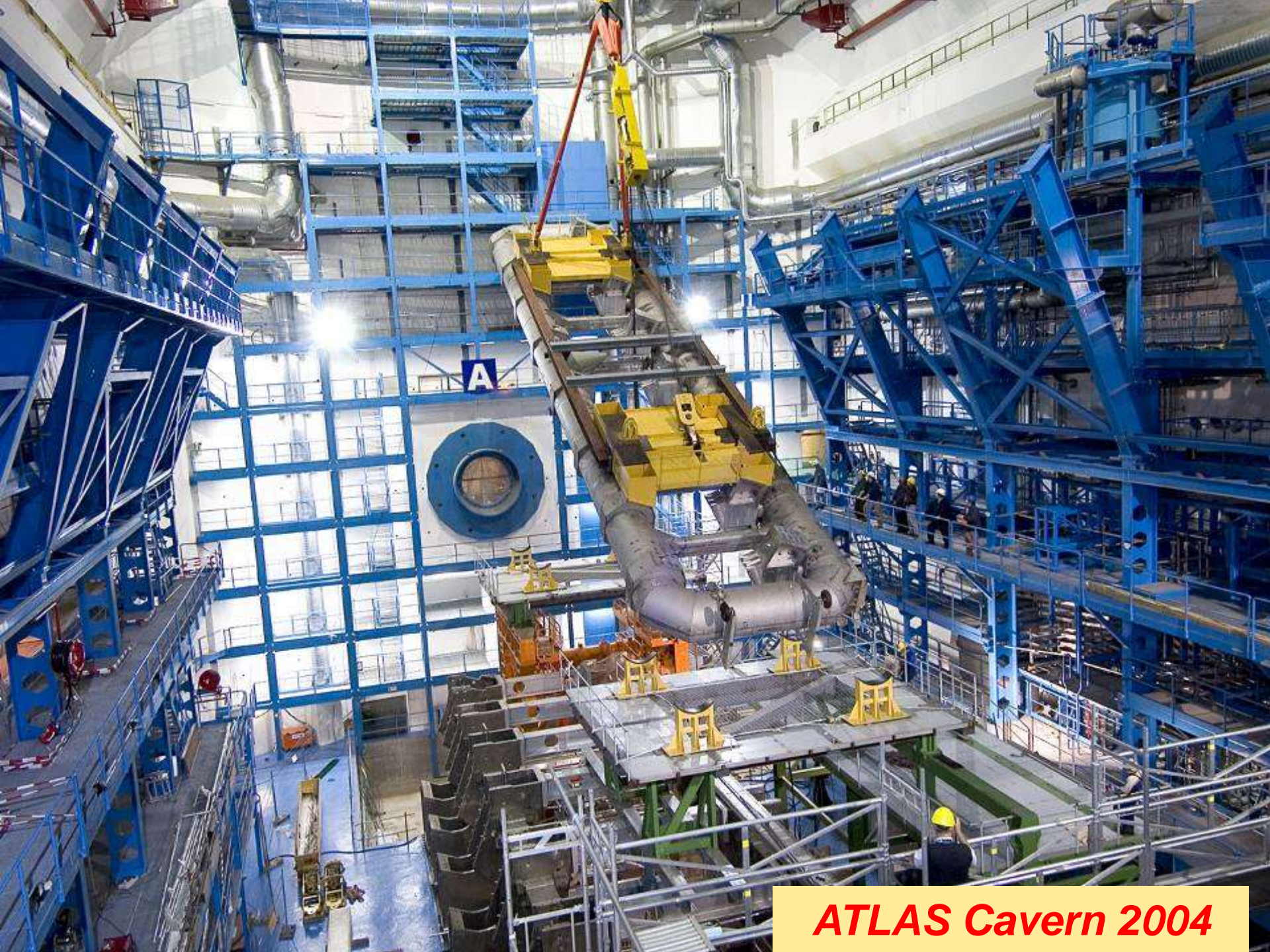


# ATLAS in Amsterdam

Length	44 m
Diameter	22 m
Weight	~7000 t
Electronic channels	$10^8$

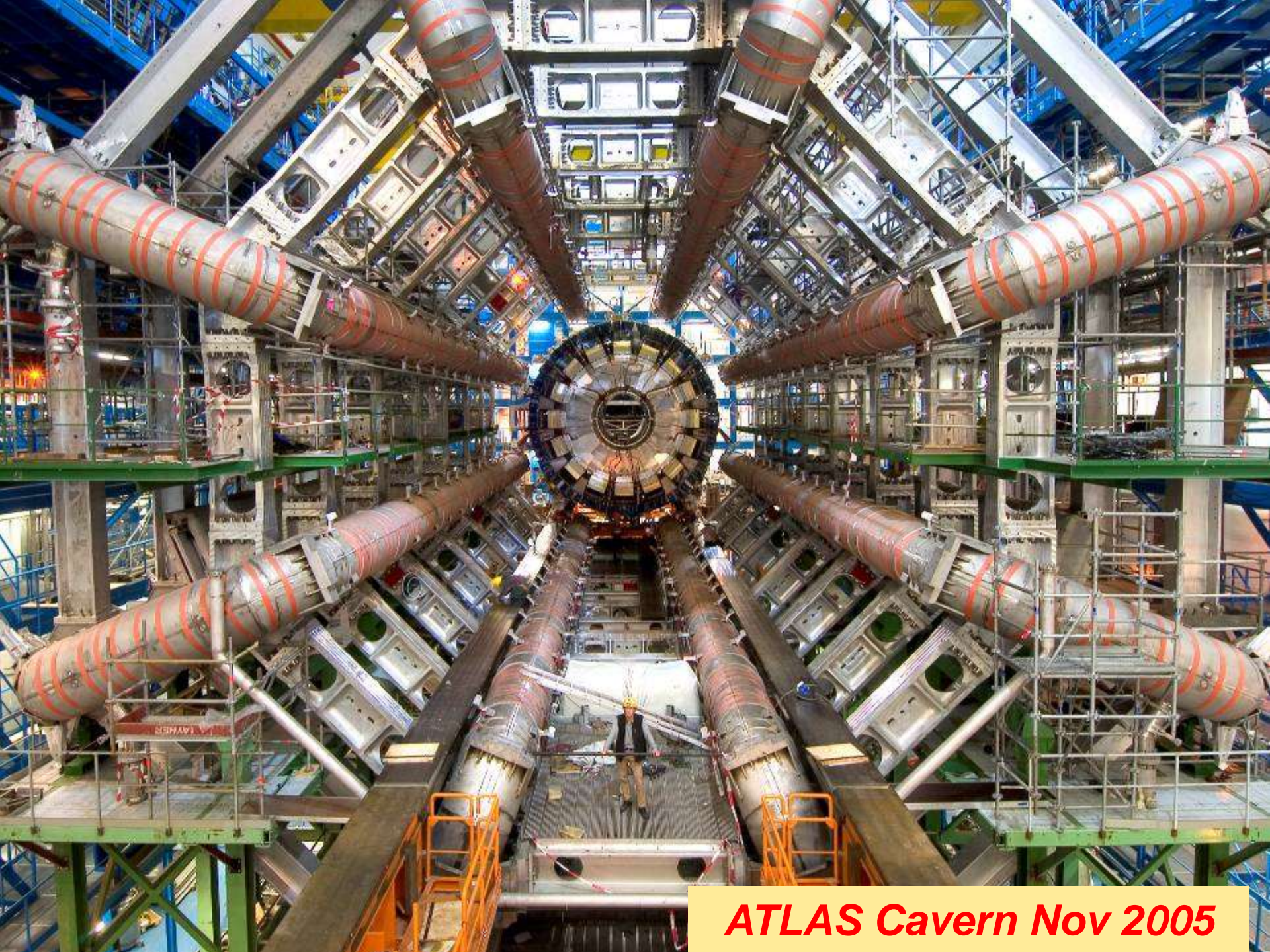






***ATLAS Cavern 2004***





***ATLAS Cavern Nov 2005***



# End-Cap Toroids integration in 2007



2 x 8 coils 4 x 4.5 m<sup>2</sup>  
20 kA, 4.1 T, 250 MJ  
140 t cold mass

Mostly made in Holland



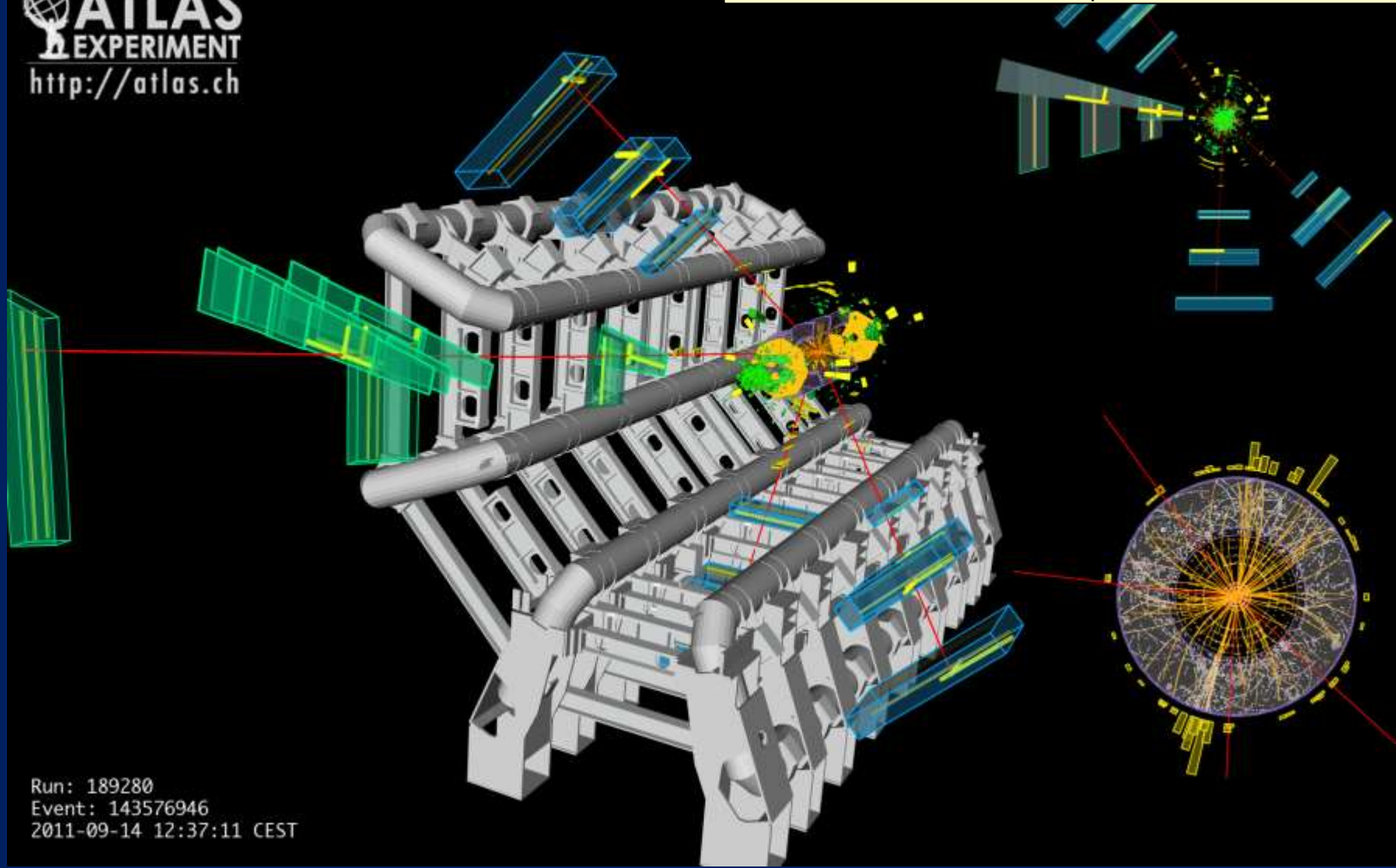


# Higgs events

$$H \rightarrow ZZ^{(*)} \rightarrow 4l \quad (4e, 4\mu, 2e2\mu)$$

$4\mu$  candidate with  $m_{4\mu} = 124.6$  GeV

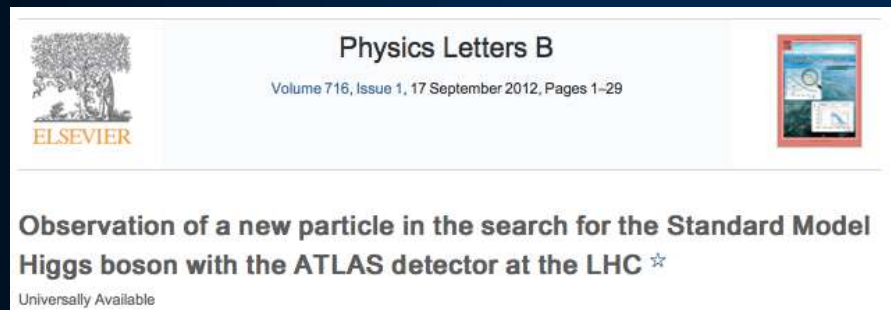
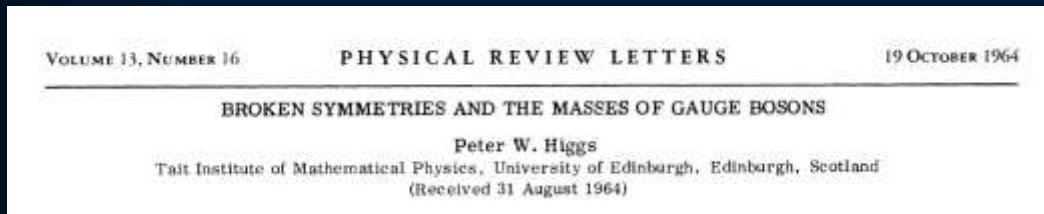
**ATLAS**  
EXPERIMENT  
<http://atlas.ch>



Run: 189280  
Event: 143576946  
2011-09-14 12:37:11 CEST



# It takes time....Mr Higgs - prelude



*"I certainly had no idea it would happen in my lifetime at the beginning, more than 40 years ago.*

*I think it shows amazing **dedication by the young people** involved with these colossal collaborations to persist in this way, on what is a really a very difficult task.*

*I congratulate them."*

**Peter Higgs, July 4<sup>th</sup>, 2012**



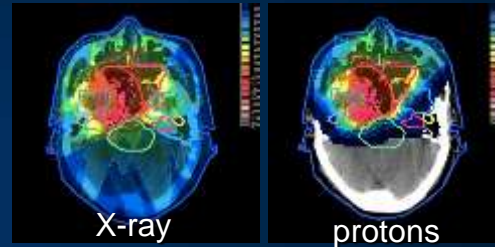
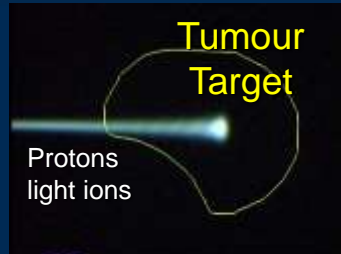
# Medical Application as an Example of Particle Physics Spin-off

Combining Physics, ICT, Biology and Medicine to fight cancer



## Hadron Therapy

Accelerating particle beams  
~30'000 accelerators worldwide  
~17'000 used for medicine



Leadership in Ion Beam Therapy now in Europe and Japan

>100'000 patients treated worldwide (45 facilities)  
>50'000 patients treated in Europe (14 facilities)

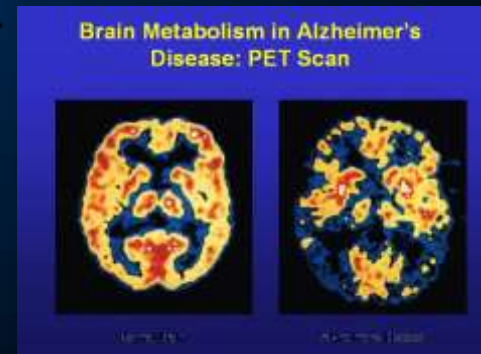
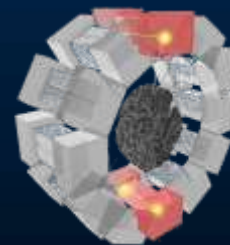


## Imaging

Clinical trial in Portugal, France and Italy for new breast imaging system (ClearPEM)



## PET Scanner



Brain Metabolism in Alzheimer's Disease: PET Scan



Detecting particles

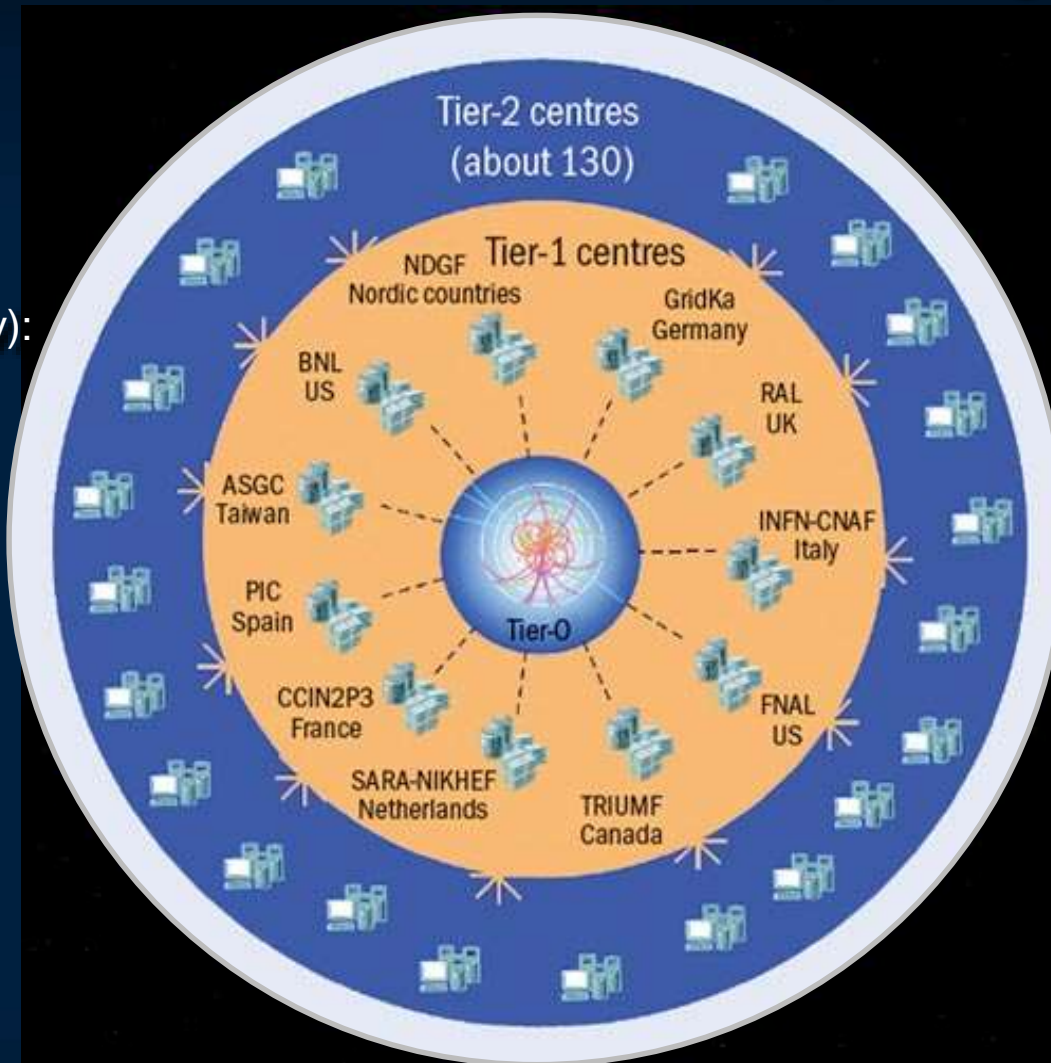


# The Worldwide LHC Computing Grid

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

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

Tier-2: Simulation,  
end-user analysis



~170 sites,  
40 countries

~500k CPU cores

500 PB of storage

> 2 million jobs/day

10-100 Gb links

**WLCG:**

An International collaboration to distribute and analyse LHC data

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





# CERN Education Activities

## Scientists at CERN

Academic Training Programme



Latin American School  
Natal, Brazil, 2011  
Arequipa, Peru, 2013



## Young Researchers

CERN School of High Energy Physics  
CERN School of Computing  
CERN Accelerator School



## Physics Students

Summer Students  
Programme



## CERN Teacher Schools

International and National  
Programmes





# The Netherlands and CERN



The Netherlands is a **founding member** of CERN

Cornelis Jan Bakker: 2<sup>nd</sup> Director General of CERN (1955-1960)

Dutch scientists have made very important contributions to the advance of Particle Physics in general and have maintained a strong involvement in CERN

## Nobel Prizes in Physics:

related to advance of Particle Physics:

1913: H. Kamerlingh Onnes: Superconductivity

1984: S. van der Meer: Accelerator physics (at CERN)

1999: M. Veltman and G. 't Hooft: theory of electroweak interactions



F. Linde  
Director  
NIKHEF

J. Engelen  
CSO, CERN  
2004 - 2008

H. ten Kate  
ATLAS

2005: CERN Visit of  
Maria van der Hoeven  
(Minister for Education,  
Culture and Science)



Media coverage in NL  
from NIKHEF home page







# The Netherlands and CERN

## Strong involvement in the LHC Experiments ATLAS, LHCb & ALICE

Particle physics in the Netherlands is coordinated by **NIKHEF**, a joint venture between **FOM** and **4 Universities**:  
Radboud University Nijmegen, Utrecht University, University of Amsterdam and Vrije Universiteit Amsterdam.



**ATLAS End Cap Toroid**

University of Twente contributes at CERN to Superconducting Magnet Technology.

**GRID computing:** Amsterdam as centre-of-excellence (via NWO BIG-GRID).

Dutch industry has played an important role.

Vacuum vessels and coils for the end cap toroids were manufactured in the Netherlands by Schelde Exotech and Brush HMA BV.





# Future ? A new 100 km tunnel, "best" option

## Collision energy

$$E_{TeV} \approx 0.3 B_T R_{km}$$

9 T & 4.6 km  $\Rightarrow$  14 TeV

## Plenty of opportunities

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