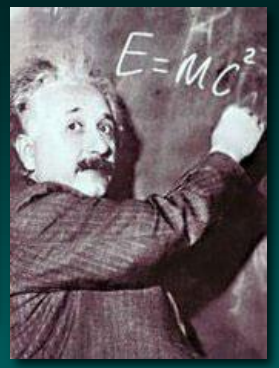
Introduction to CERN and its Scientific Program

Livio Mapelli
CERN - Physics Dept.

CERN
Research – Innovation – Education – People

Physics results
Have we discovered the Higgs?

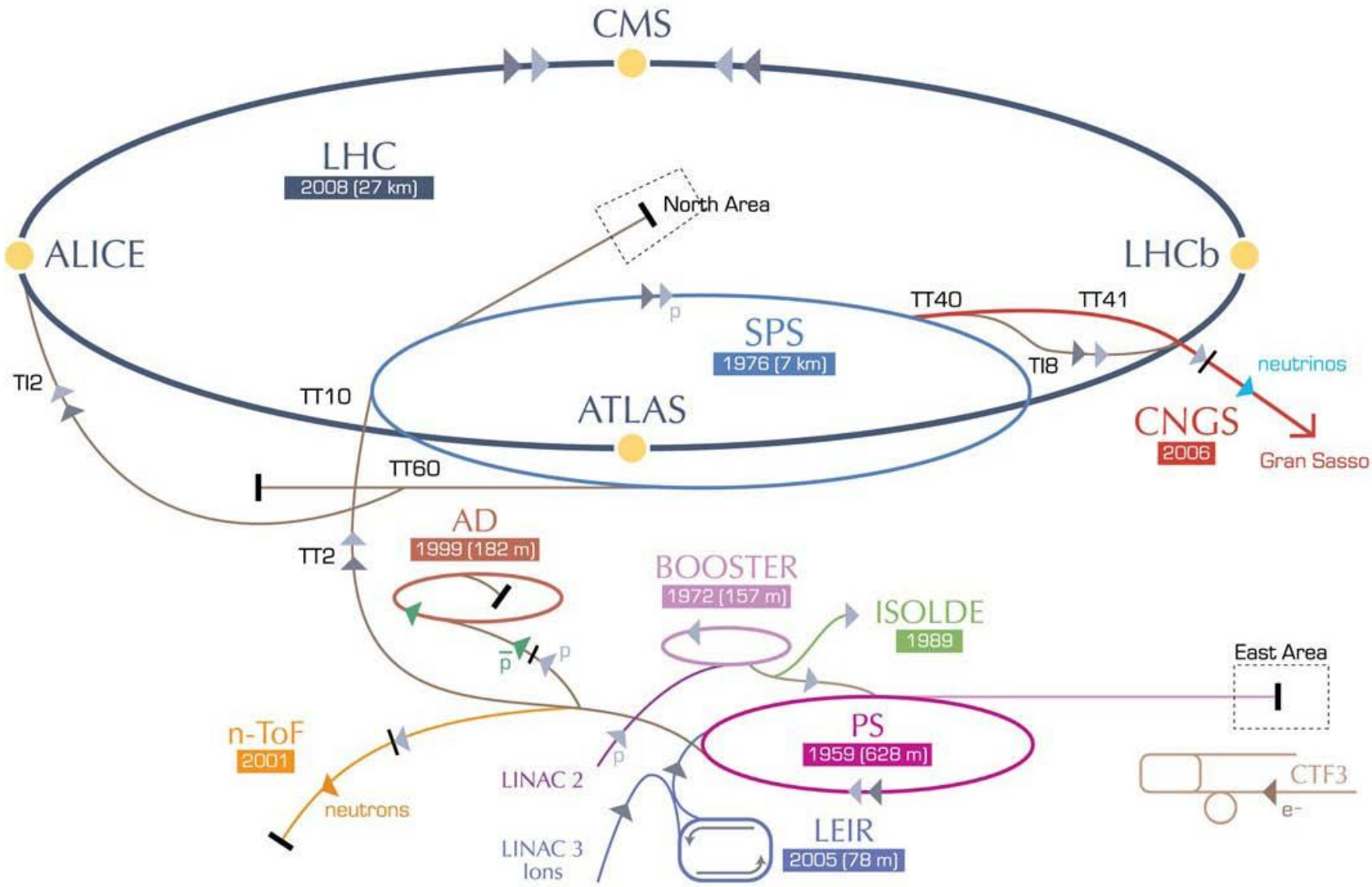
The Mission of CERN



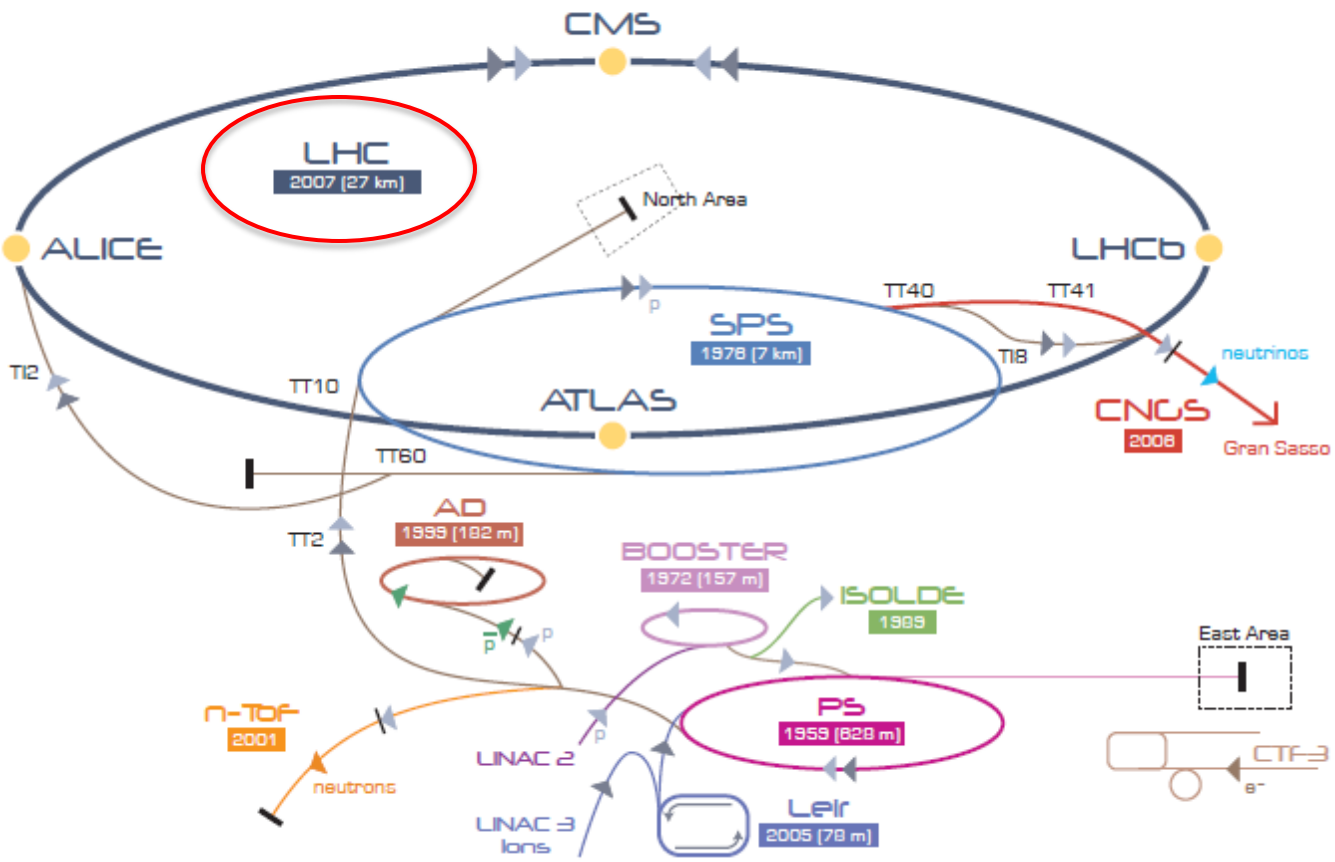
- Push back the frontiers of knowledge

  E.g. the secrets of the Big Bang … wh… s the matter like within the first moments of the univ… stence?

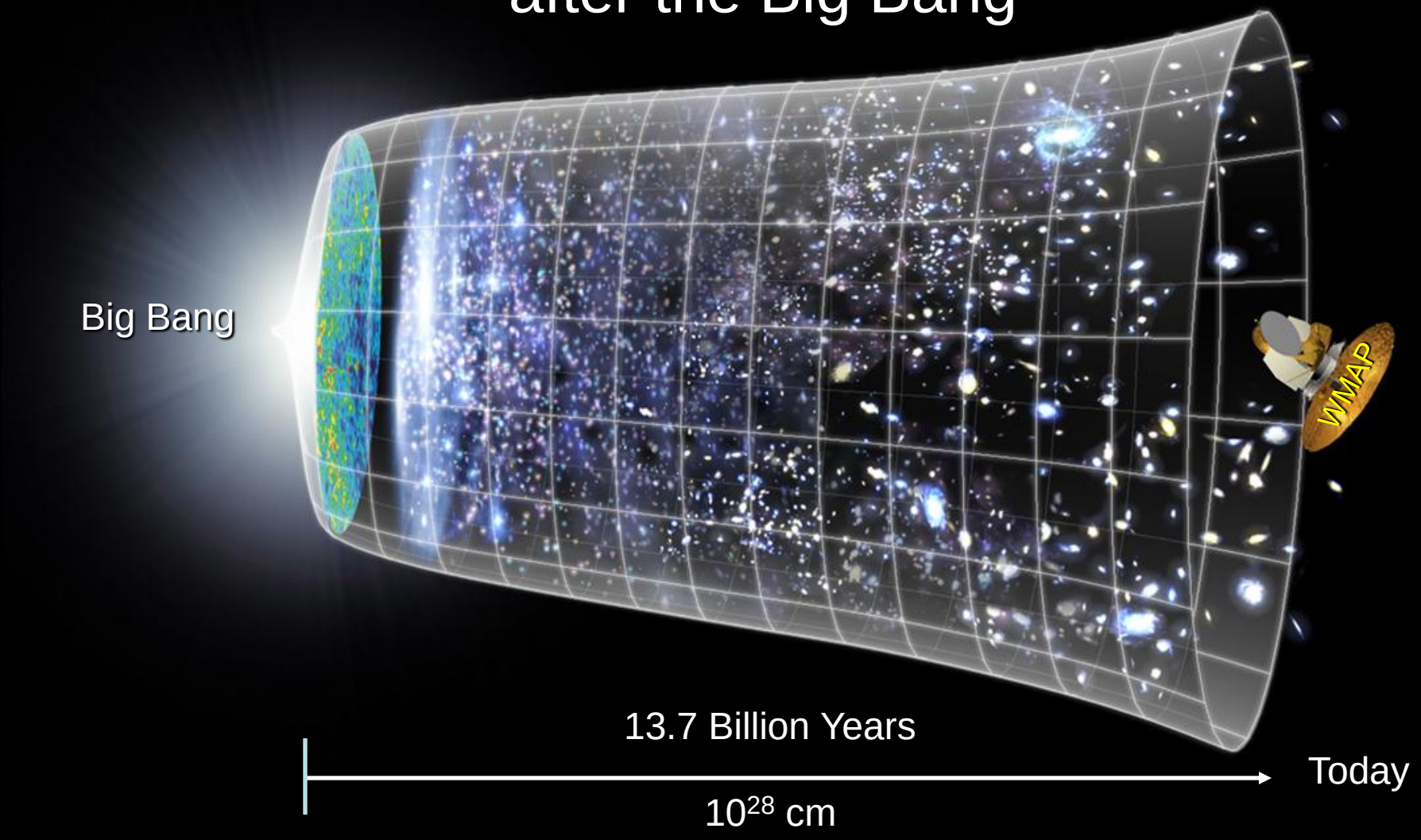
The CERN Accelerators



Large Hadron Collider

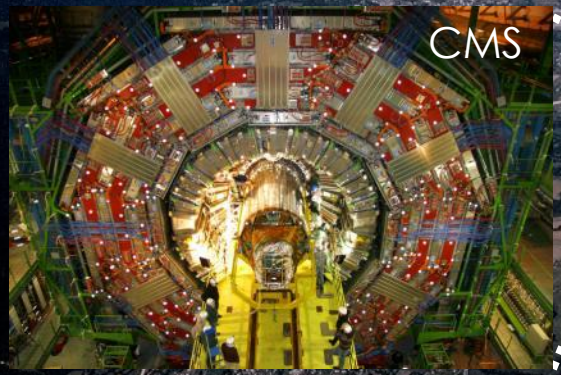


Today's Scientific Challenge:
to understand the very first moments of our Universe after the Big Bang

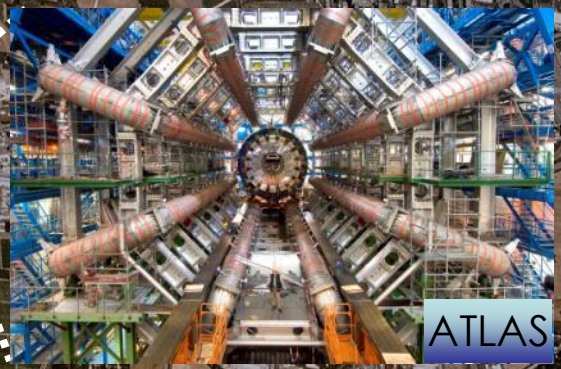


Enter a New Era in Fundamental Science

Search for Higgs Boson, Supersymmetry (Dark matter) , new dimensions,…

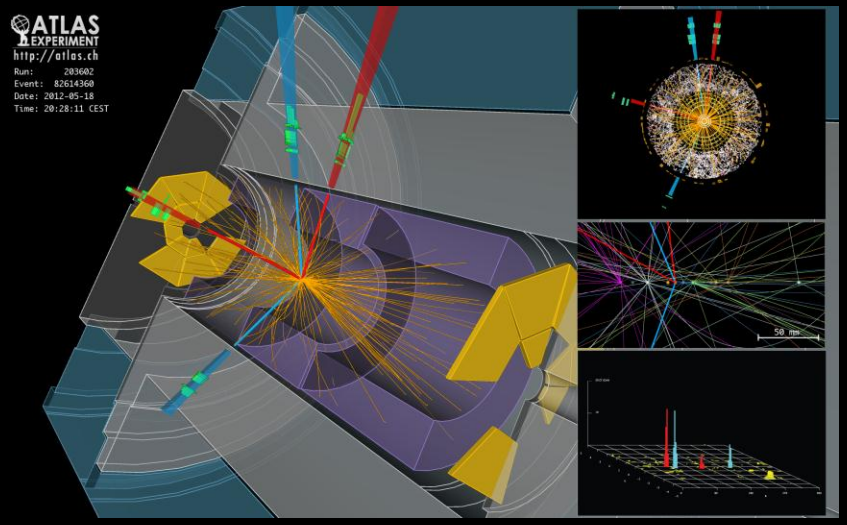


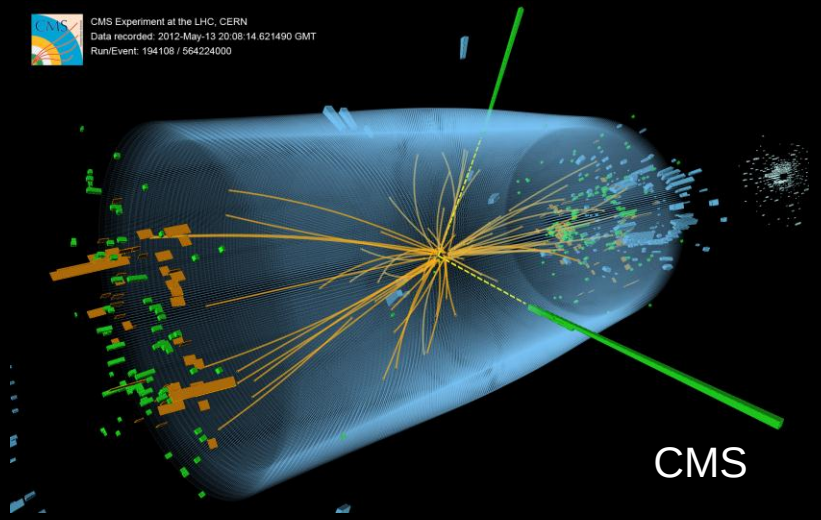
Exploration of a new energy frontier
in p-p and Pb-Pb collisions



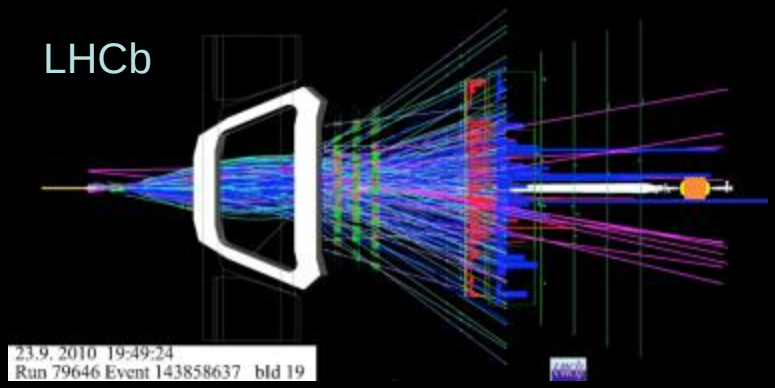
The experiments at the LHC

p-p collisions at √s = 7-8 TeV : Higgs-like particle at 125 Gev/c^2 in ATLAS and CMS

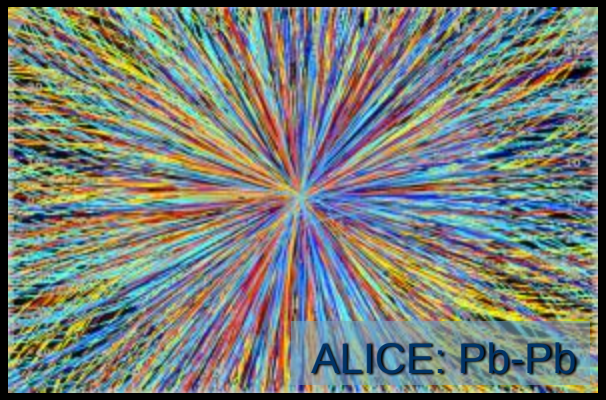




LHCb

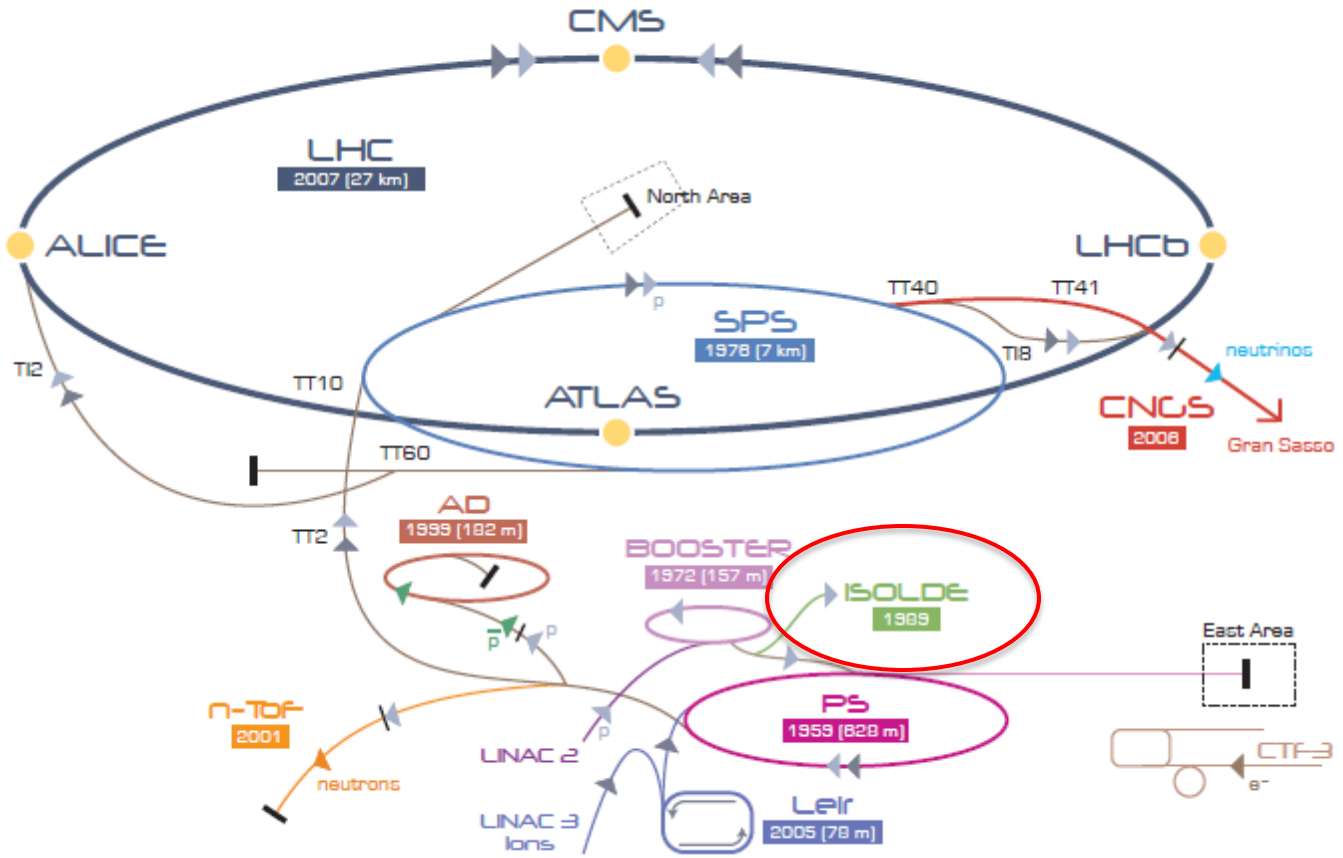


Pb-Pb collisions
√s = 2.76TeV/N



→ Brilliant performances of LHC, experiments and GRID computing

Isolde


CMS
LHC
2007 (27 km)
North Area
ALICE
LHCb
TT40
TT41
p
SPS
1978 (7 km)
TI8
neutrinos
TI2
TT10
ATLAS
CNGS
2006
Gran Sasso
TT60
AD
1999 (182 m)
TT2
BOOSTER
1972 (157 m)
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1989
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n-ToF
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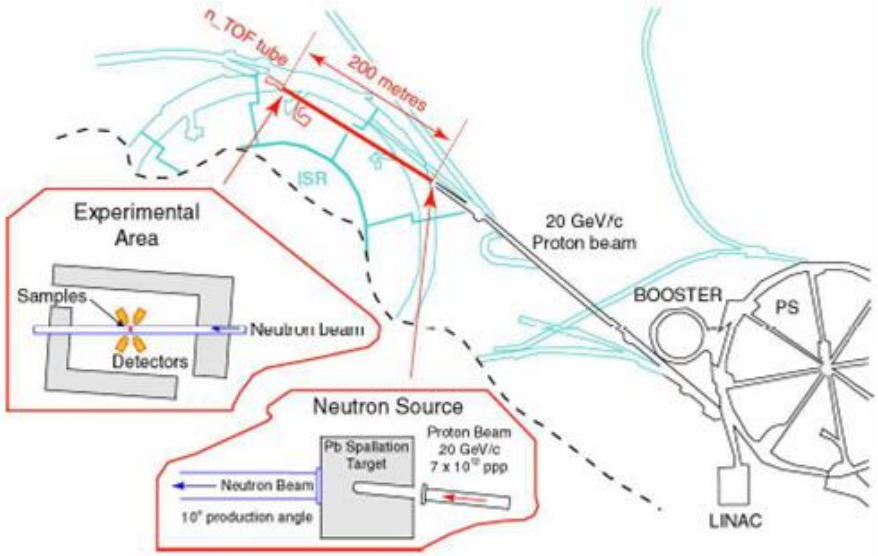
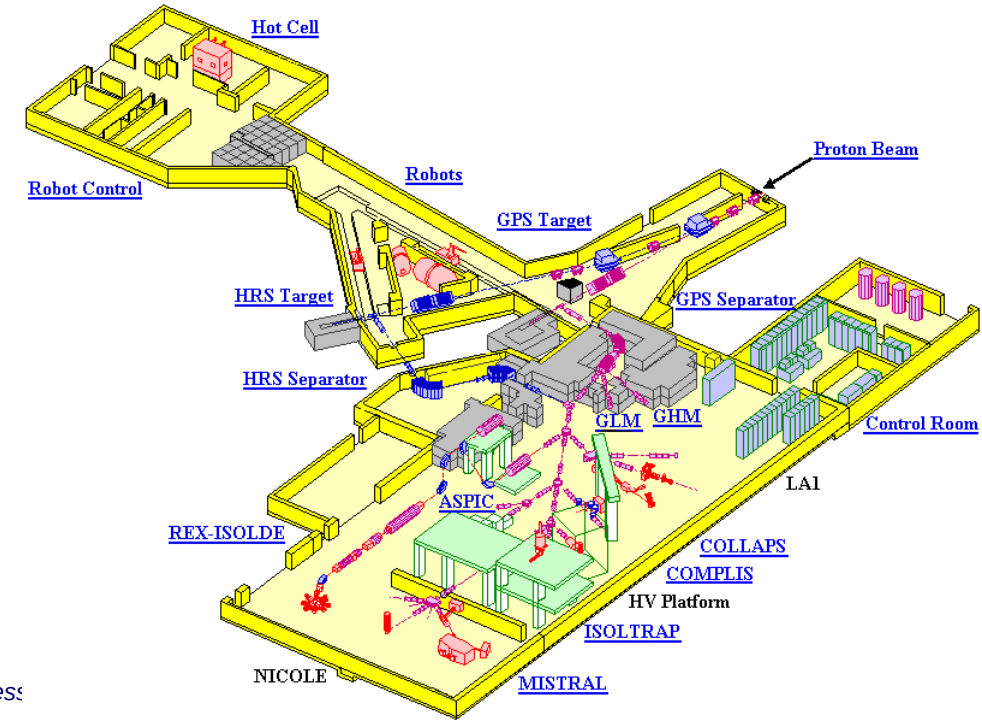
LINAC 2
neutrons
CTF3
e-
LINAC 3
Ions
Leir
2005 (78 m)

Nuclear Physics nTOF & ISOLDE

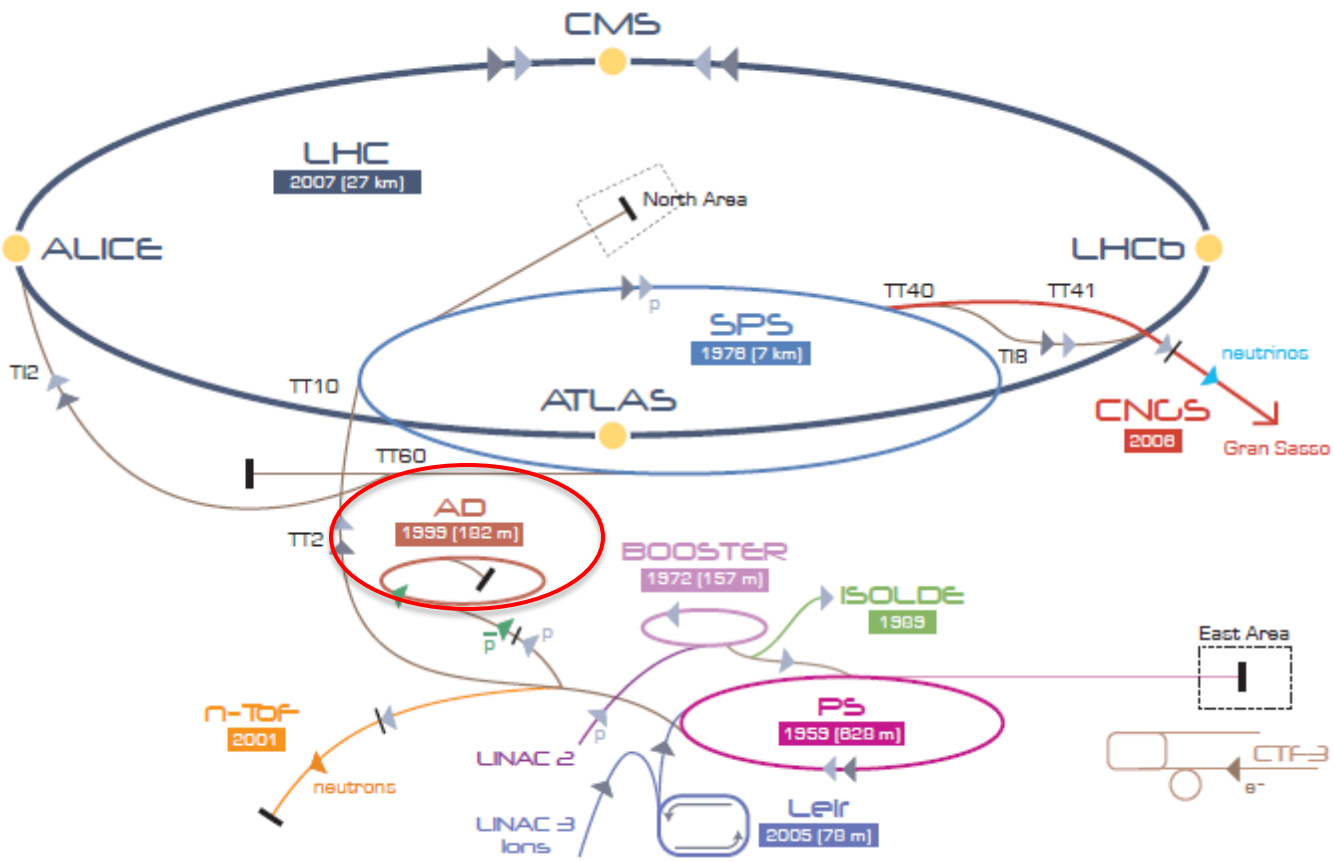


Neutron cross sections
Astrophysics
Burning of nuclear waste

Radioactive Ions Beams
Nuclear physics
Astrophysics
Solid States Physics



Antiprotons Decelerator

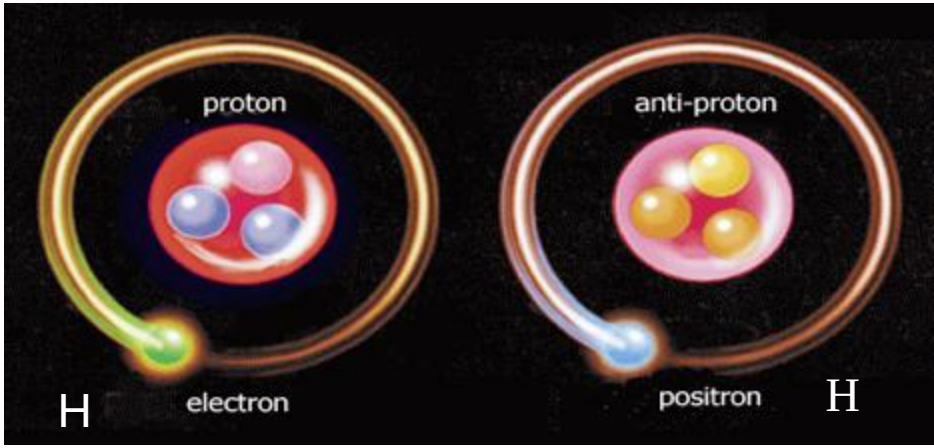


Antimatter Physics

Matter-Antimatter comparison

Very fundamental in our theory of physics

$m=\bar{m}$ $g=\bar{g}$



ASACUSA
ATRAP
ALPHA

Trapping $\bar{H}$ in a magnetic bottle

AEGIS

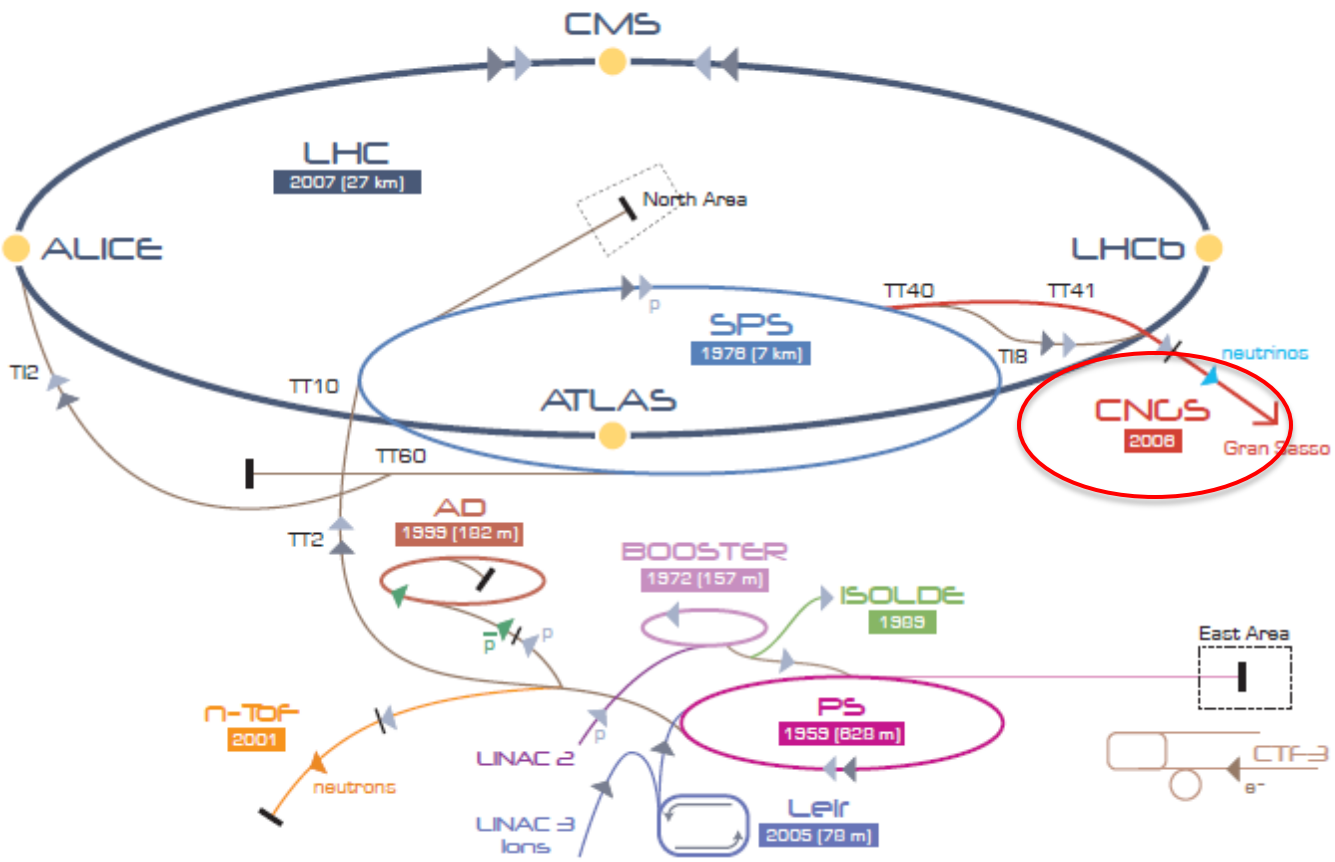
Look at $\bar{H}$ free fall
Galileo's experiment for antimatter !

ACE

Biological effect of $\bar{p}$
Possible use for cancer therapy

CNGS

CERN Neutrinos to Gran Sasso



CNGS: neutrinos to Gran Sasso in Italy

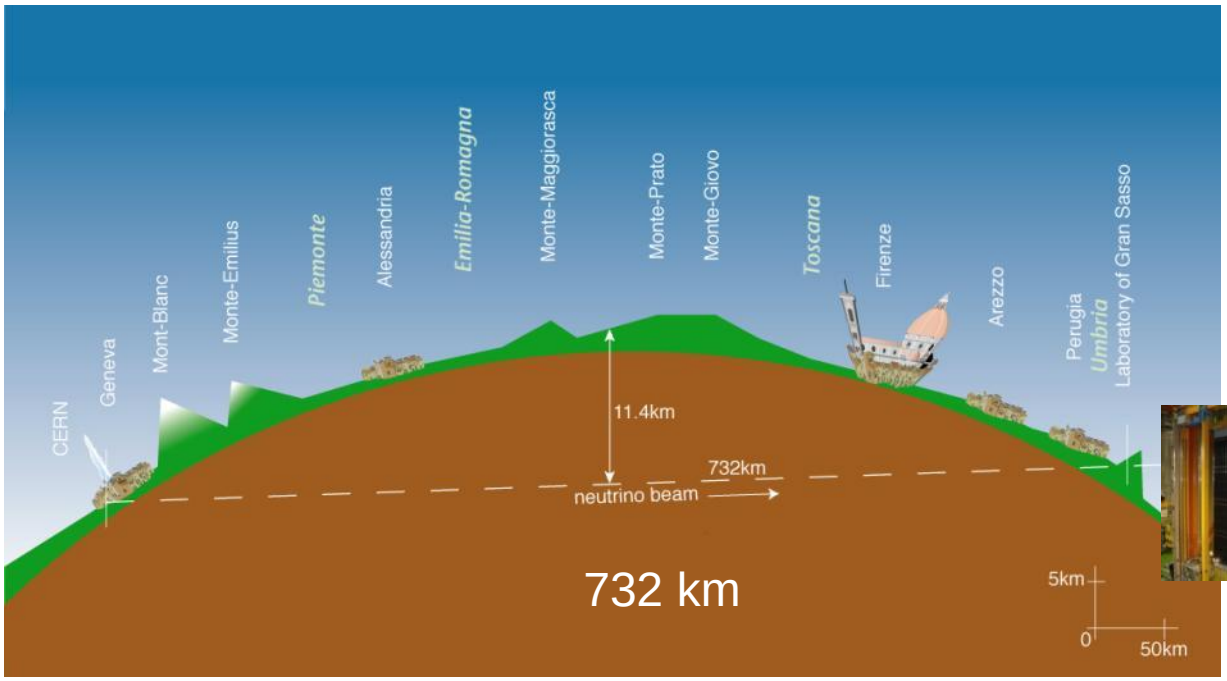
Like quarks, neutrinos exist in different flavors ν_μ ν_τ ν_e

Contrary to what was believed until ~ 15 years ago neutrinos have a small mass and **their flavour oscillates**

$$\nu_\mu \Leftrightarrow \nu_\tau \qquad \nu_\mu \Leftrightarrow \nu_e$$

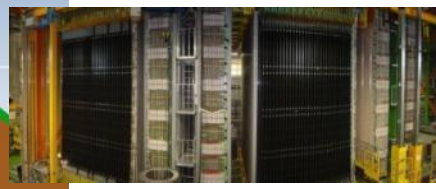
CERN

ν_μ

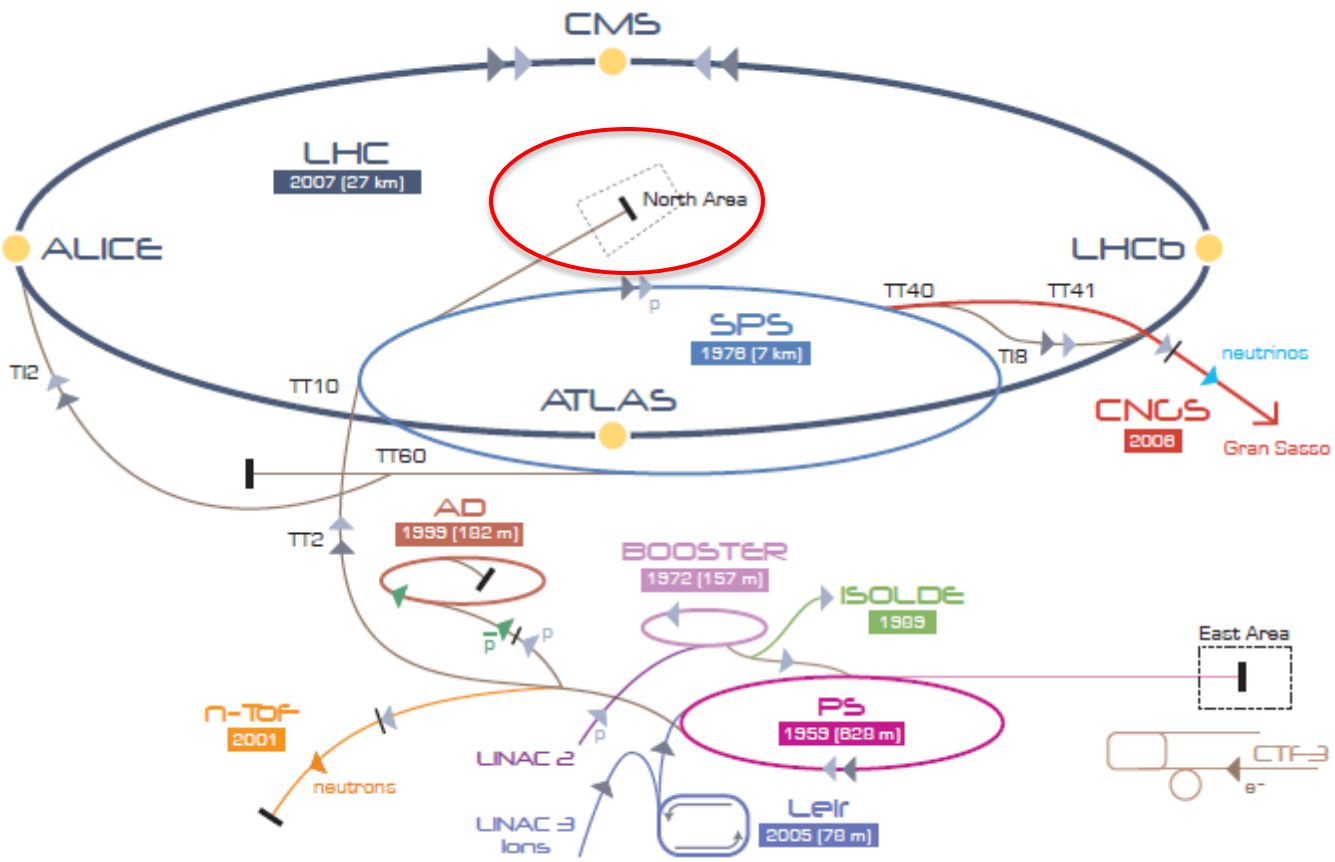


OPERA
Gd Sasso

ν_τ ???



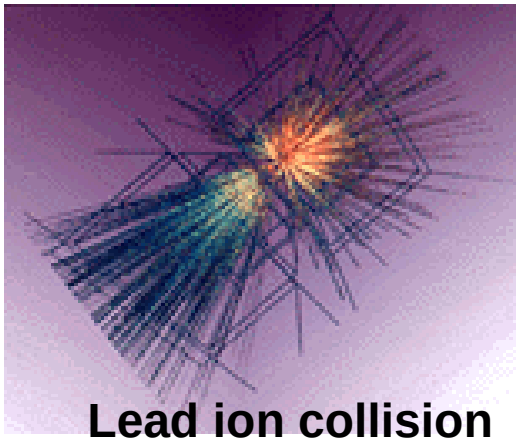
SPS North Hall



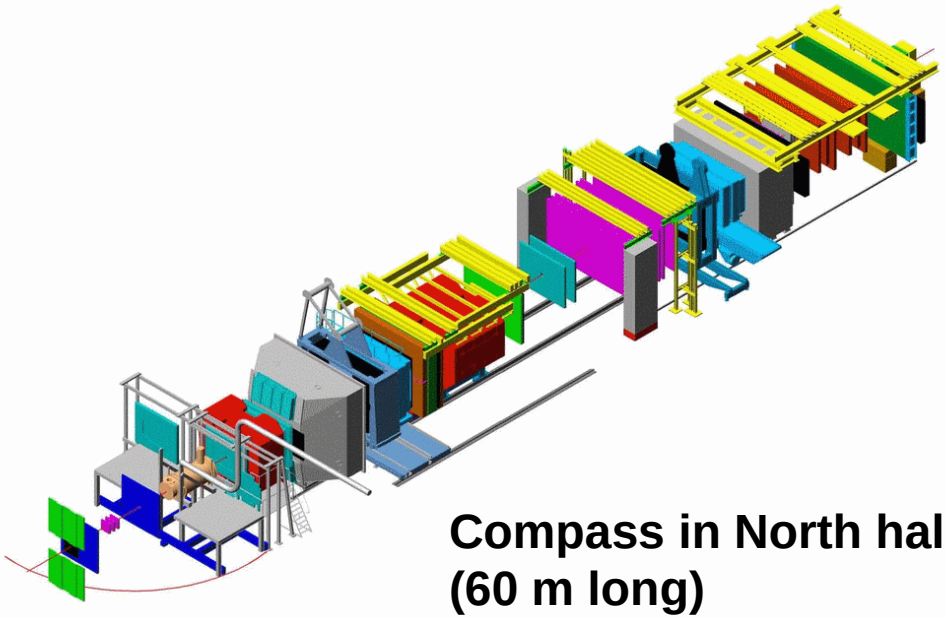
Fixed Target Physics in (1-100GeV) range

Lower energy experiments at PS or SPS allow precision measurements and comparison with theory. **Deviations can be sign of new physics at higher energies**

DIRAC : **pionic atoms**
COMPASS **: Muon Spin physics**
NA62 : **rare K decays**
NA63 : **electromagnetism** in extreme conditions
NA61 ions physics: **quark gluon plasma**



Lead ion collision

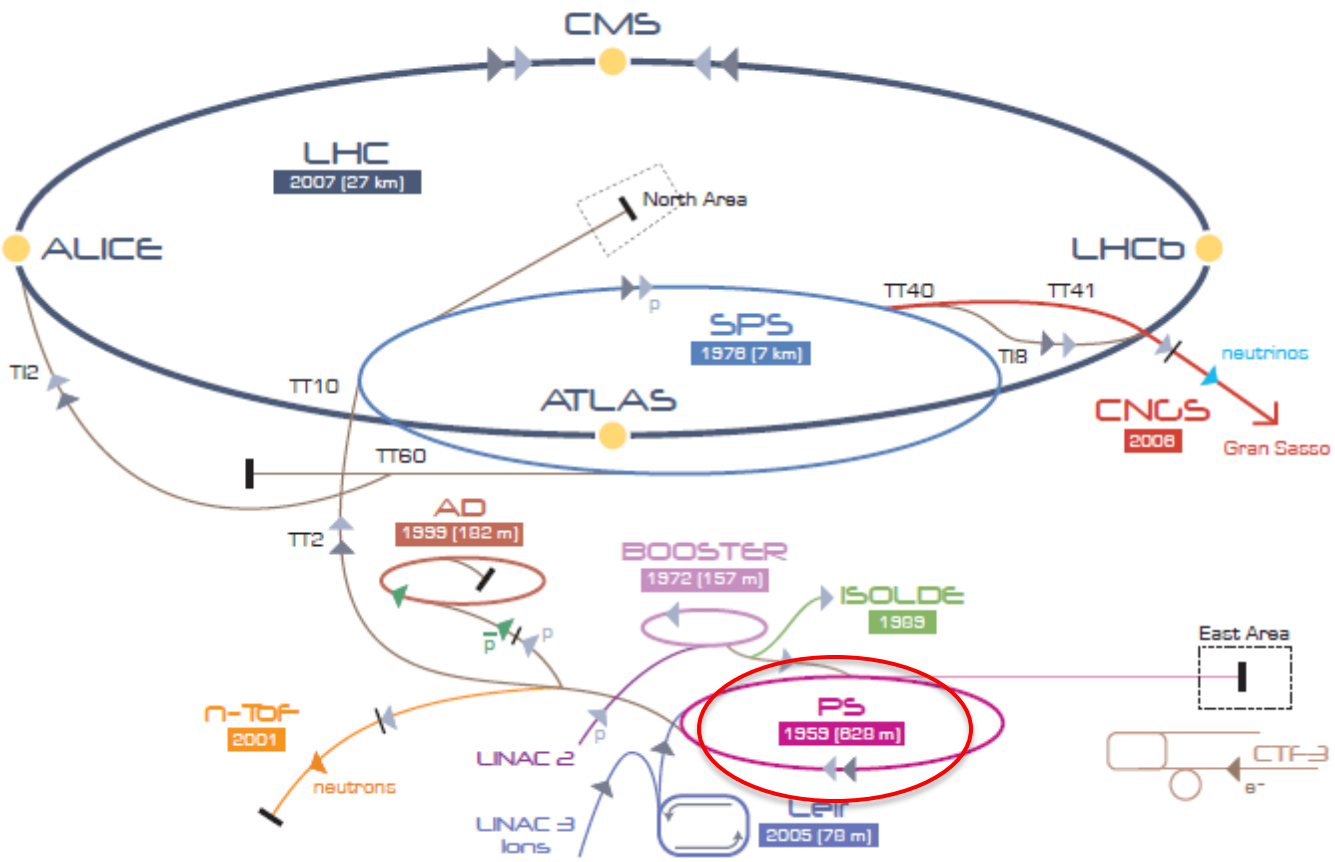


Compass in North hall (60 m long)

NA62 P326

NEW!

PS East Hall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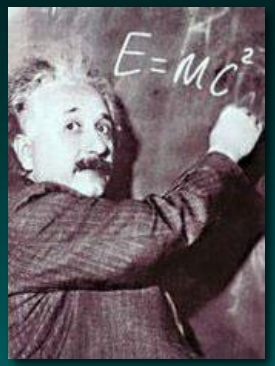
2001
PS
1959 [628 m]
neutrons
LINAC 2
CTF-3
LINAC 3
Ions
LEIR
2005 [78 m]

Study effect of cosmic rays on clouds formation
(cosmic rays “simulated “ by T11 beam, clouds created in a large climatic chamber)

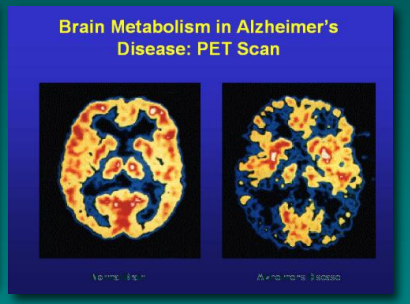
Innovation
Education
CERN
uniting people
Research

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

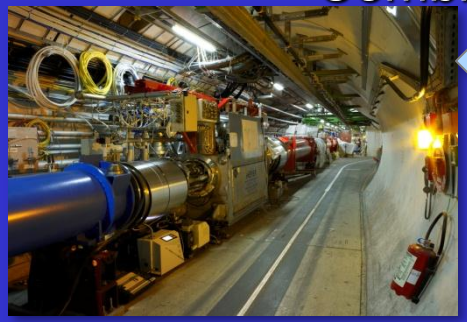
  Medicine - diagnosis and therapy

Innovation Education
CERN
uniting people
Research

From fundamental science to everyone's life

Example: Medical applications

Combining Physics, IT, Biology and Medicine to fight cancer

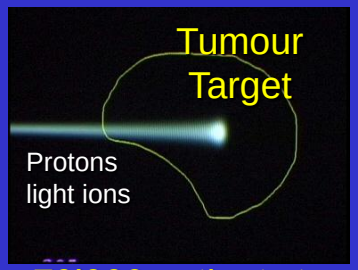


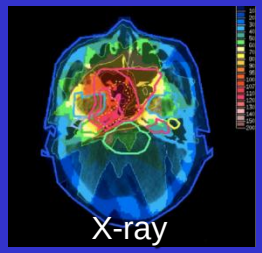
Accelerating particle beams

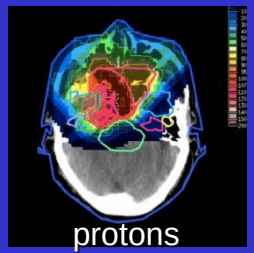
~30'000 accelerators worldwide

~17'000 used for medicine

Hadron Therapy



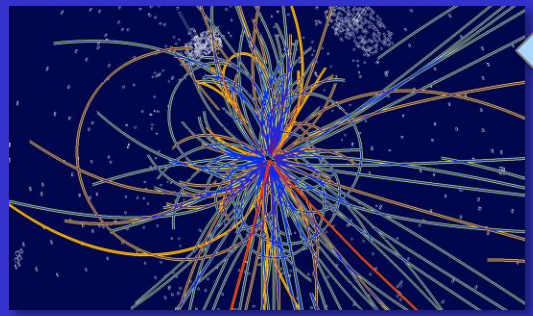




Leadership in Ion Beam Therapy now in Europe and Japan

>70'000 patients treated worldwide (30 facilities)

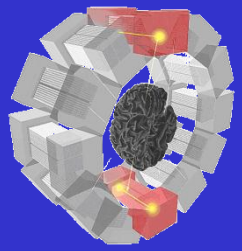
>21'000 patients treated in Europe (9 facilities)



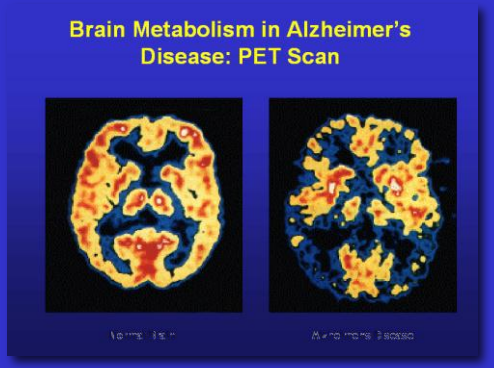
Detecting particles

Imaging

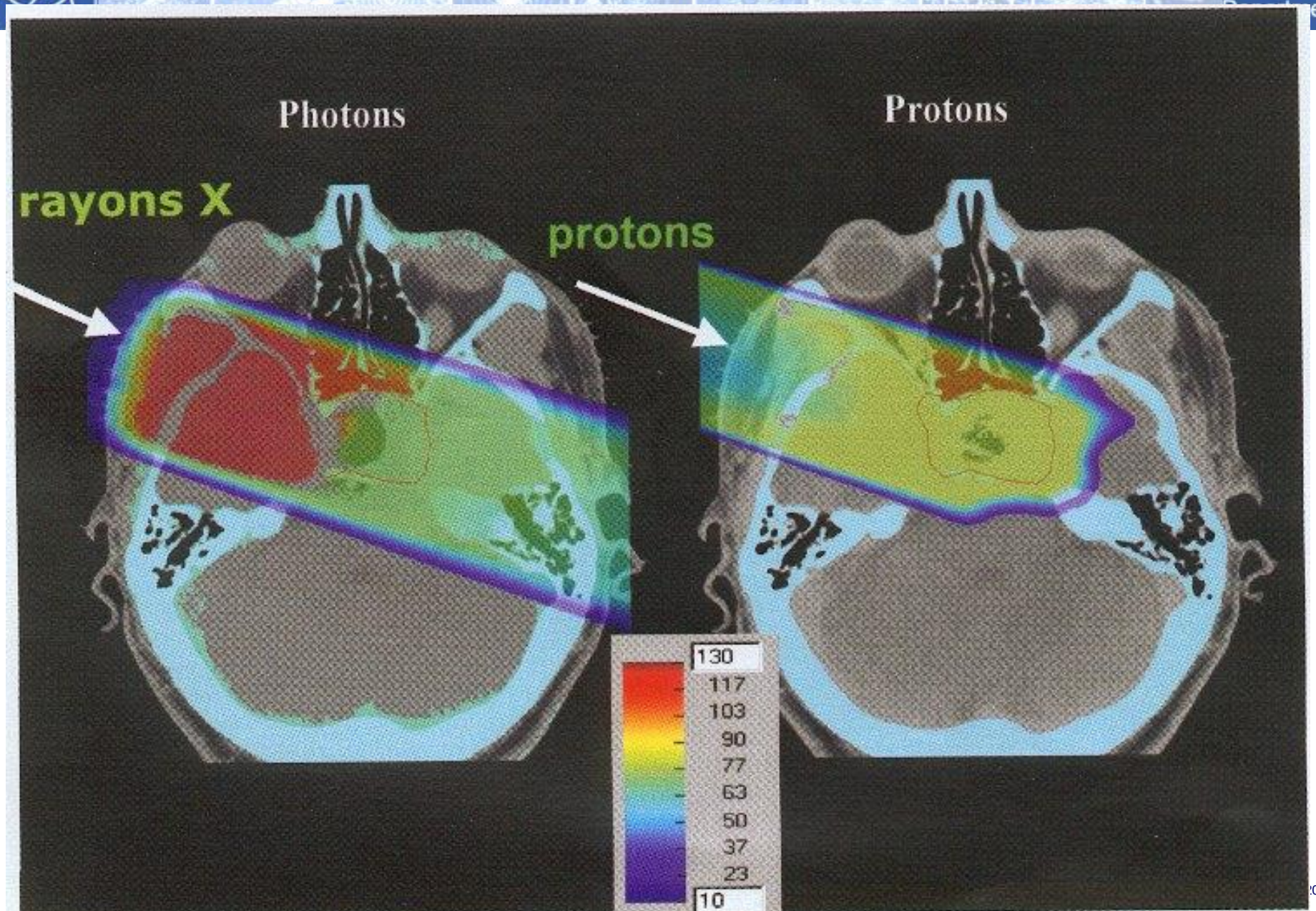
Clinical trial in Portugal for new breast imaging system (ClearPEM)



PET Scanner: Positron Emission Tomography

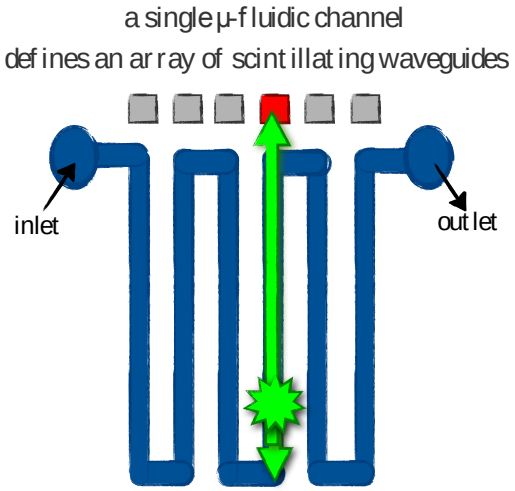


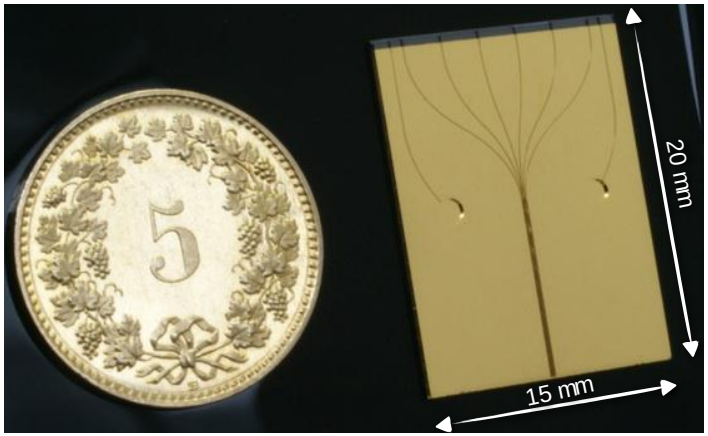
Advantages of hadron therapy



Beam monitors for hadron therapy

R&D in microtechnology





Microfluidic scintillation detectors under study for hadron therapy beam monitoring.

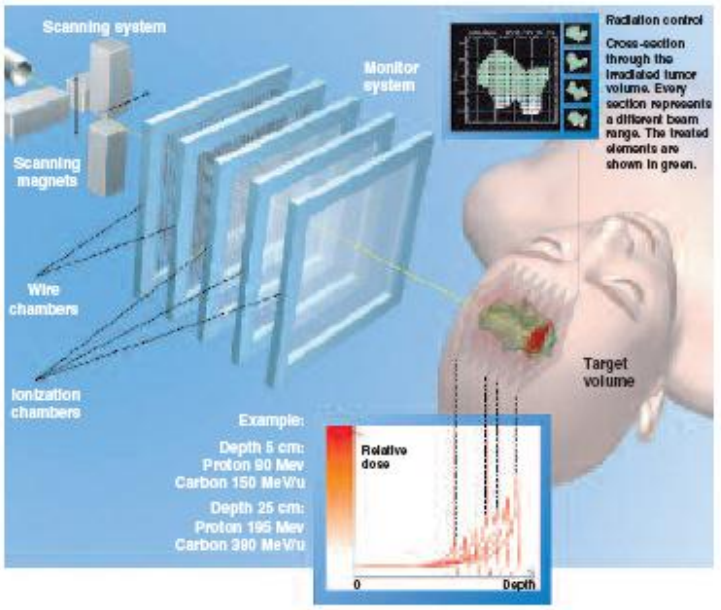
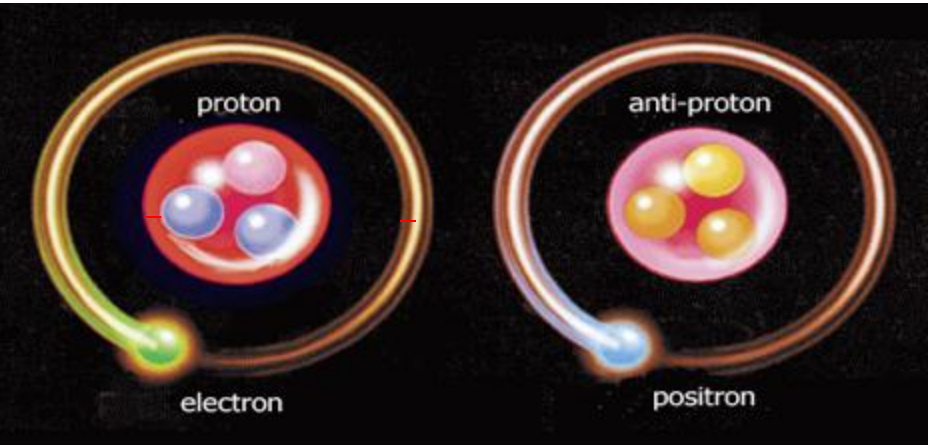


Figure 4 - Dose delivery with a 3D active scanning technique (courtesy of Siemens Medical). http://www.tumorionline.it/articoli.php?archivio=yes&vol_id=422&id=5005

Use of antimatter



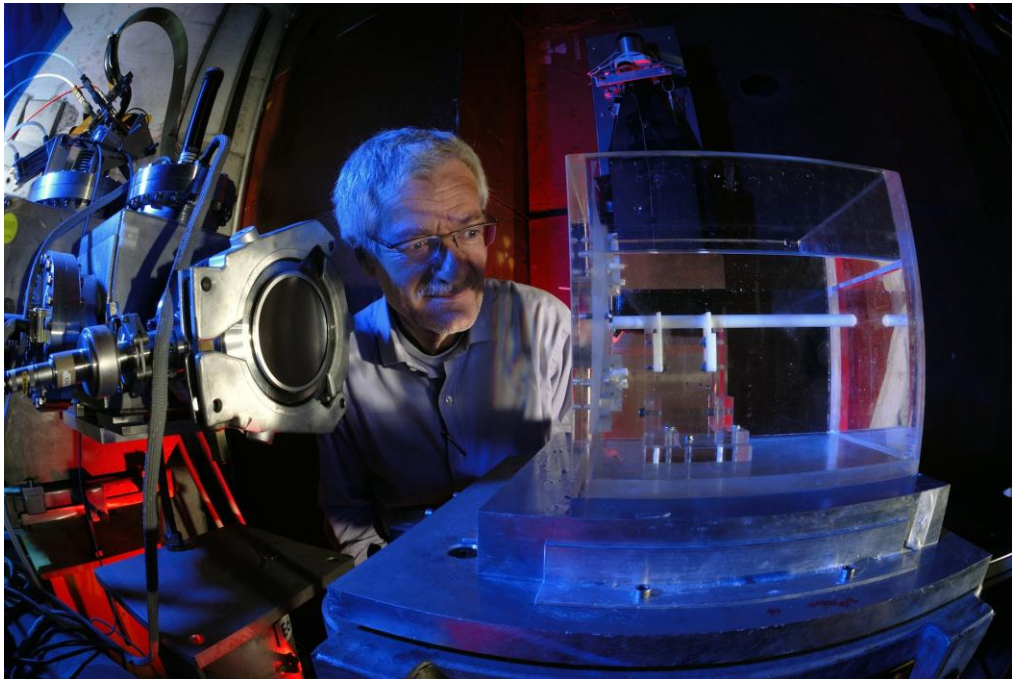
ACE

Antiproton Cell Experiment

Antiprotons vs cancer cells

Biological effect of anti-p

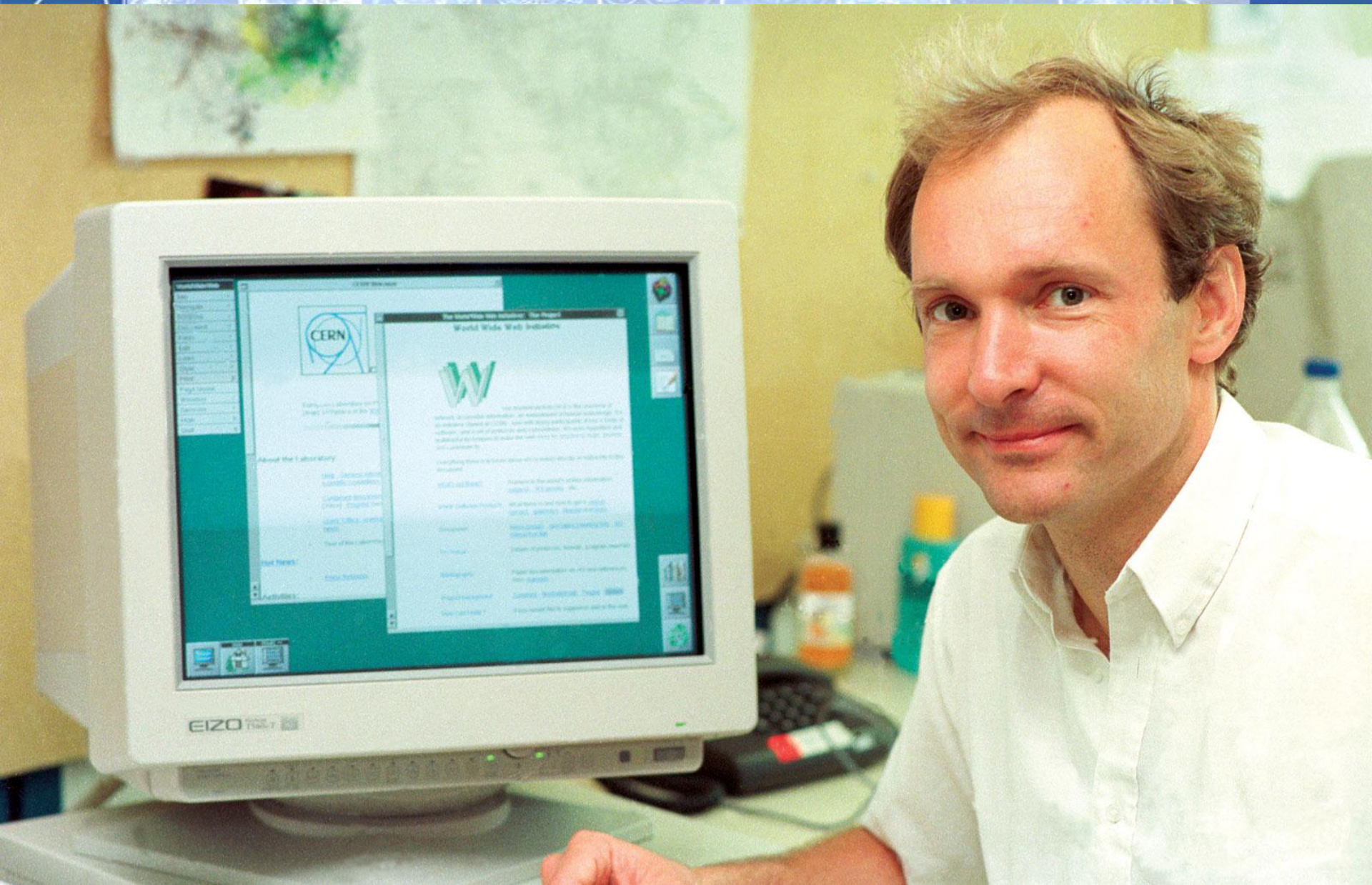
Possible use for cancer therapy



Spinoff - The World Wide Web

(Tim Berners-Lee)

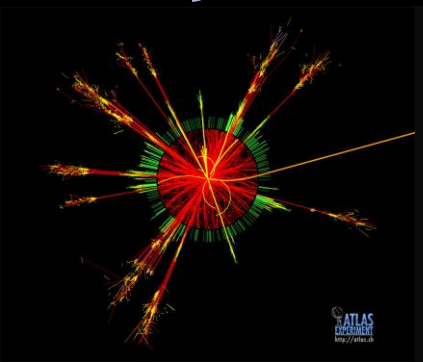
PH Physics Department

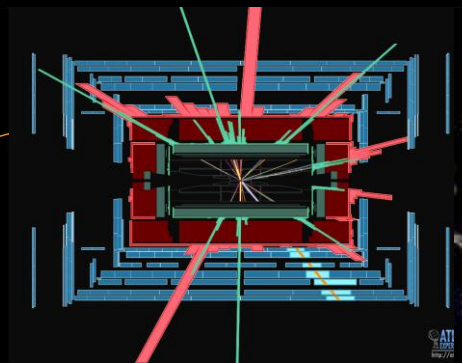


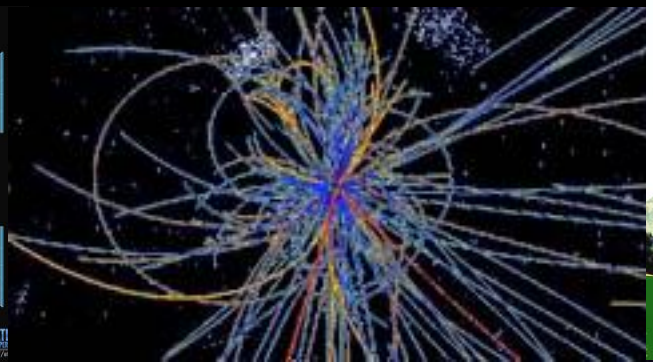
The LHC data

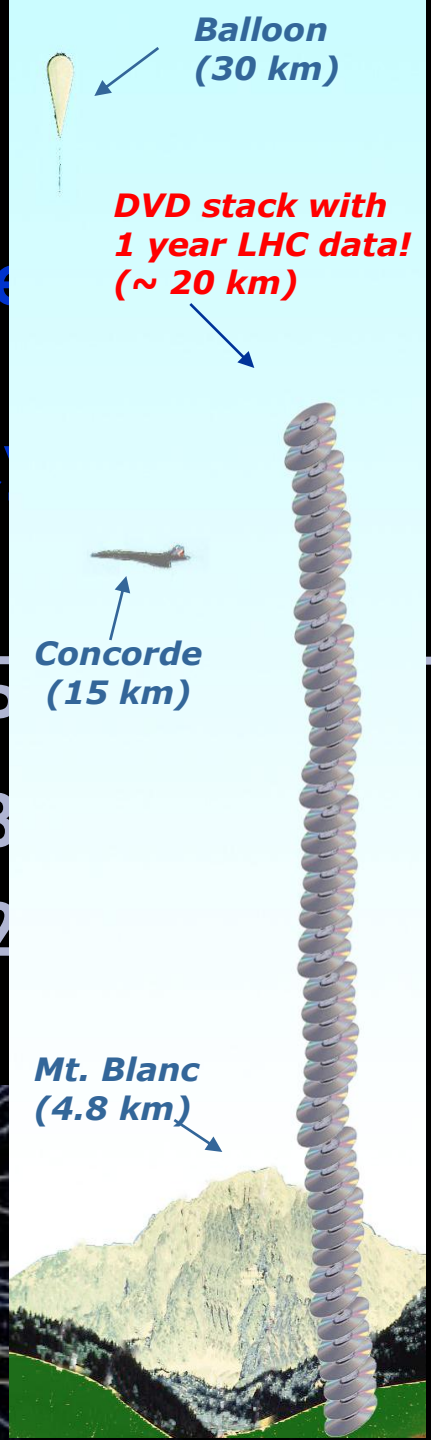
- 40 million events (pictures) per second
- Select (on the fly) the ~500 interesting e
  second to write on tape
- "Reconstruct" data and convert for anal
  "physics data" [→ the grid…]

(x4 experiments x15 years)	Per event	P
Raw data	1.6 MB	3
Reconstructed data	1.0 MB	2
Physics data	0.1 MB	





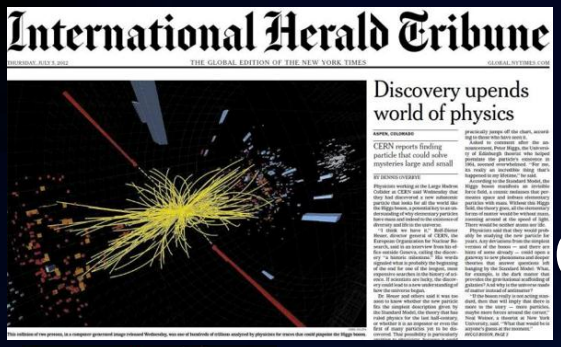


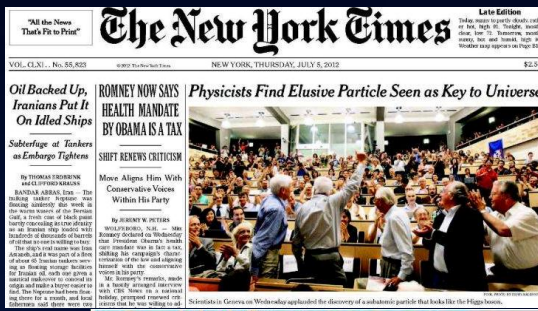


Physics results

Have we discovered the Higgs?

4 JULY 2012
CERN Press conference


International Herald Tribune
THE GLOBAL EDITION OF THE NEW YORK TIMES
Discovery upends world of physics
CERN reports finding particle that could solve mysteries large and small

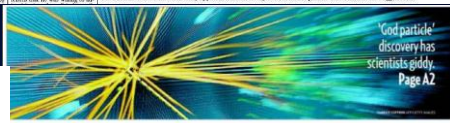

The New York Times
Late Edition
Oil Backed Up, Iranians Put It On Idled Ships
Subterfuge at Tankers as Embargo Tightens
ROMNEY NOW SAYS HEALTH MANDATE BY OBAMA IS A TAX
SHIFT RENEWS CRITICISM
Move Aligns Him With Conservative Voices Within His Party
Physicists Find Elusive Particle Seen as Key to Universe


The Economist
In praise of charter schools
Britain's banking scandal spreads
Volkswagen overtakes the rest
A power struggle at the Vatican
When Lonesome George met Nora
A giant leap for science
Finding the Higgs boson


ヒッグス粒子 発見か
新素粒子検出 年内に結論
日米欧2チーム


EDIÇÃO LISBOA Qui 5 JUL 2012
Por dia, Deco recebe 87 casos por causa de sobreendividamento p14
HOJE: HERÓIS MARVEL
publicação P
Milhares de moradores de bairros sociais em risco de perderem RSI
A mudança está a passar despercebida, mas deve afectar milhares de beneficiários de RSI que vivem em habitação social e agora, morar numa casa camarária é uma forma de rendimento Portugal, 12
Ministério de Portas contrata funcionário de CDS-PP
Lusófona diz que Relvas deu todos os dados para ter curso
CIENCIA
"PARTÍCULA DE DEUS" EXISTE, MAS A HISTÓRIA NÃO ACABA AQUI
Destaque, 2/3


Spécial Festival d'Avignon
La 66e fête du théâtre démarre le 7 juillet
Le Monde
Le Monde des livres
Les coups de cœur de la rédaction
Science : la matière dévoilée
Le boson de Higgs, particule manquante pour expliquer l'Univers, vient d'être découvert
Les physiciens du CERN de Genève ont prouvé son existence à 99,9999 %
IMPÔTS CE QUI VA CHANGER
7,2 milliards de plus dès 2012
Réforme fiscale à l'automne
ALGÉRIE L'INDÉPENDANCE
Une fête sans panache
La souffrance, mais pas de haine
Ces livres qui explorent l'histoire


'God particle' discovery has scientists giddy. Page A2


The Gazette
MONTREAL | THURSDAY, JULY 5, 2012 | SINCE 1778 | BREAKINGNEWS.ATMONTREALGAZETTE.COM
EL PAIS
EL PERIÓDICO GLOBAL EN ESPAÑOL
A solas con la prueba del VIH
De Villota pierde el ojo derecho
Pistorius estará en los Juegos
Hallada la partícula clave para a comprensión del universo
La Audiencia Nacional imputa a toda la cúpula de Bankia


В ТЕАТРЫ БУДУТ ПУСКАТЬ ПО МОБИЛЬНЫМ ТЕЛЕФОНАМ
WWW.MK.RU
МК
№144 (25.980)
5 июля 2012
ПОСЛЕДНИЙ КИРПИЧ В СТЕНУ МИРОЗДАНИЯ
«КРЕМЛЕВСКИЕ» САМОЛЕТЫ ПРИШЛОСЬ МЕНЯТЬ НА ПЕРЕПРАВЕ
МЕТРО СПУСТЯТ НА ВОДУ


AD
ALGEMEEN DAGBLAD
donderdag 5 juli 2012
EINDELIJK GELIJK NA 48 JAAR
Zieke Kaj en zijn moeder toch samen in de VS
SPORTWERELD VAN PERSIE


Frankfurter Allgemeine
ZEITUNG FÜR DEUTSCHLAND
Fünf Tote bei Geiselnahme in Karlsruhe
Masse macht's
Große Mehrheit im


IMPORTANT MATTER
Scientists claim to have discovered 'God particle'
MOVIE PLOT
Iron Man film company looks to China for screen success
DANGEROUS MOVE
Freeing captured animals may lead to disasters
CHINA DAILY
THURSDAY, July 5, 2012
chinadaily.com.cn


THE TIMES OF INDIA
UNDER FIRE FROM OPPN, AKHILESH ROLLS BACK CAR BONANZA FOR MLAS
ADJUSTING DIESEL PRICE BETTER THAN TAXING CARS, SAYS MONTEK
BLADE RUNNER PISTORIUS SET FOR OLYMPIC HISTORY: TO RUN 400M & RELAY
Big bang moment: Scientists may have found 'God particle'
Adarsh scam: Finally, CBI charges sheets 13


THE HINDU
INDIA'S NATIONAL NEWSPAPER SINCE 1878
RARE CHOLA INSCRIPTIONS
MAY HAVE BEEN POISONED
SUBBARAO ON MFIS
RAHANE RETURNS
Elusive particle found, looks like Higgs boson
CERN physicists hail evidence of game-changing discovery of subatomic particle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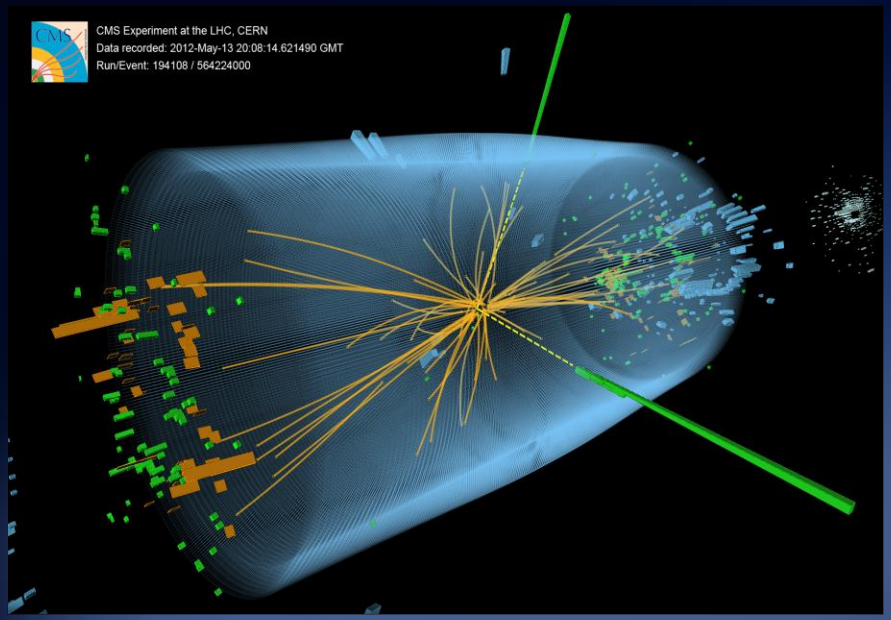
Svolta scientifica
La particella che può svelare i segreti dell'universo
UN'AZIENDA IN OSTAGGIO

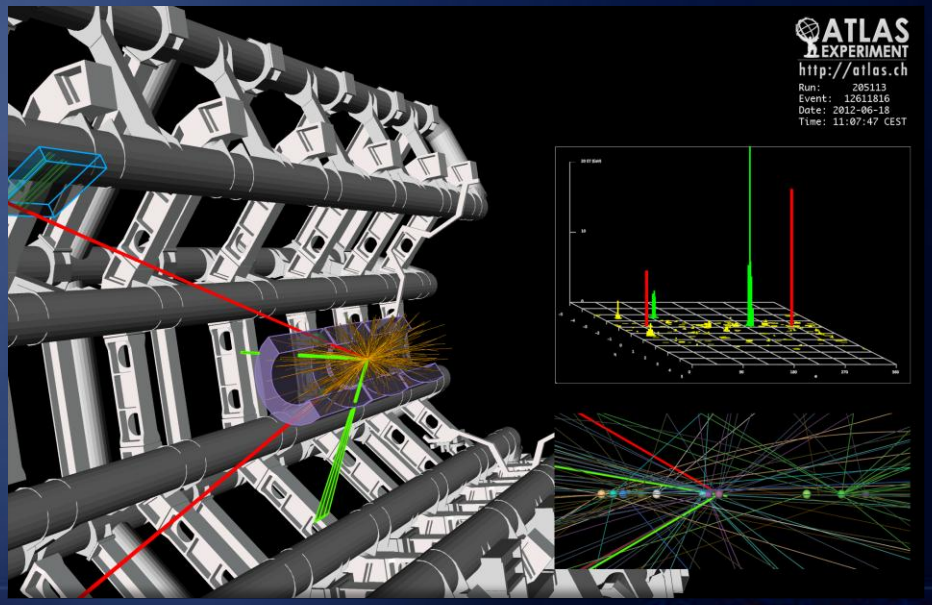

gazeta WYBORCZA.PL
Ukraińcy biją się o język. Rosyjski
Cząstkę Higgsa fizycy najpierw wymyślili, potem szukali 40 lat
BOSKA MASA
Po tym odkryciu świat już nigdy nie będzie taki sam.


আনন্দবাজার পত্রিকা
বিজ্ঞানের 'ঈশ্বর' দর্শন
সত্যেন্দ্রনাথকে বিনম্র প্রণাম
'পেয়েছি, যা খুঁজছিলাম'

4 July 2012: CERN press conference

“CERN experiments observe particle consistent with long-sought Higgs boson”





ATLAS EXPERIMENT

Have we discovered the Higgs?

Have we discovered the Higgs?

- Why search for the Higgs?
  - The Standard Model
- Need tools of unprecedented performance and complexity
  - The LHC machine and experiments

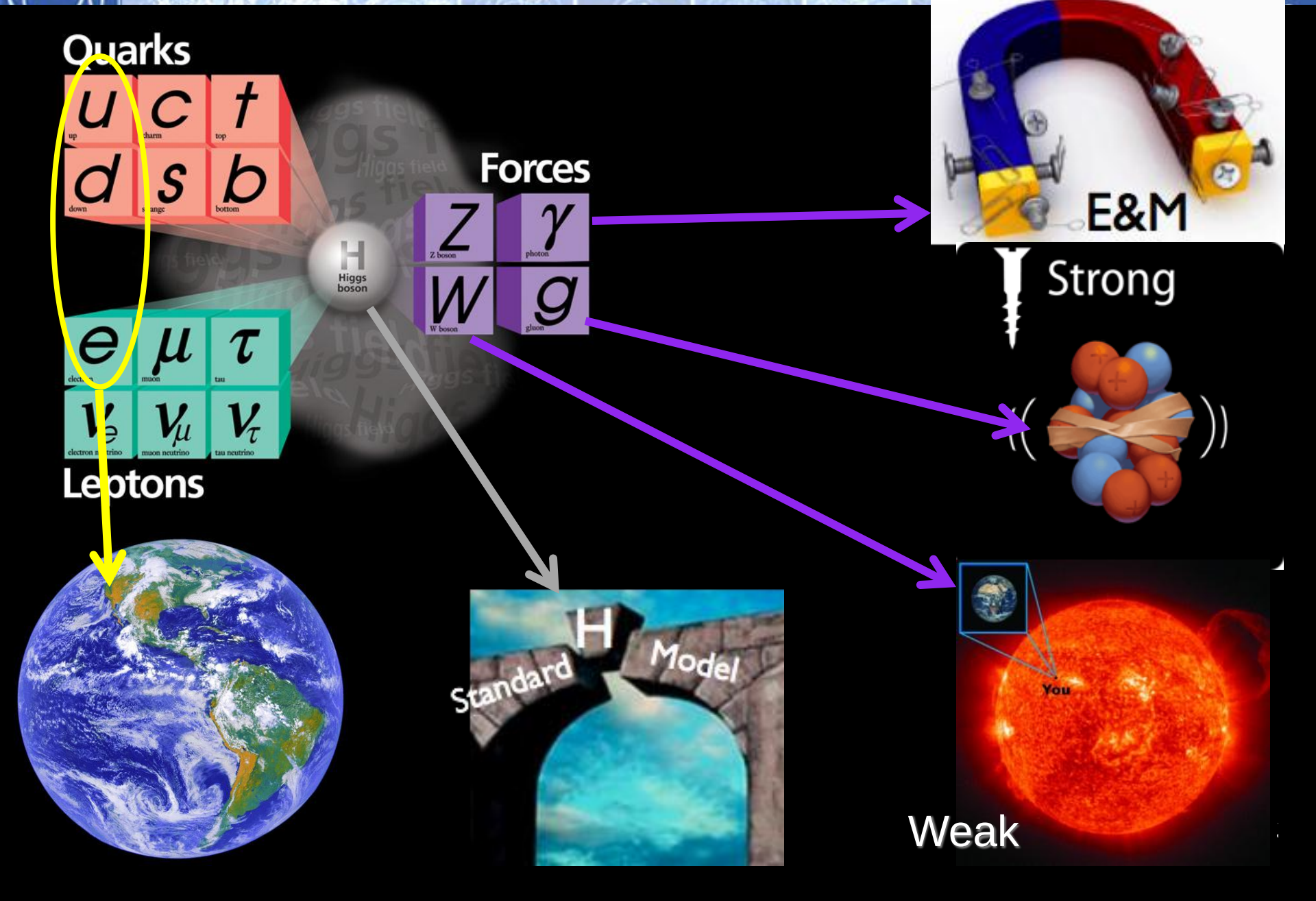
- ***We have recently observed an object at 125 GeV/c^2***
  - ***It is Higgs-like, but it could be new physics***

- What next?
  - What are we missing to claim Higgs or no-Higgs?
  - Is there physics beyond the SM?
  - A look at the near future

Why search for the Higgs?

A step backward

The Standard Model



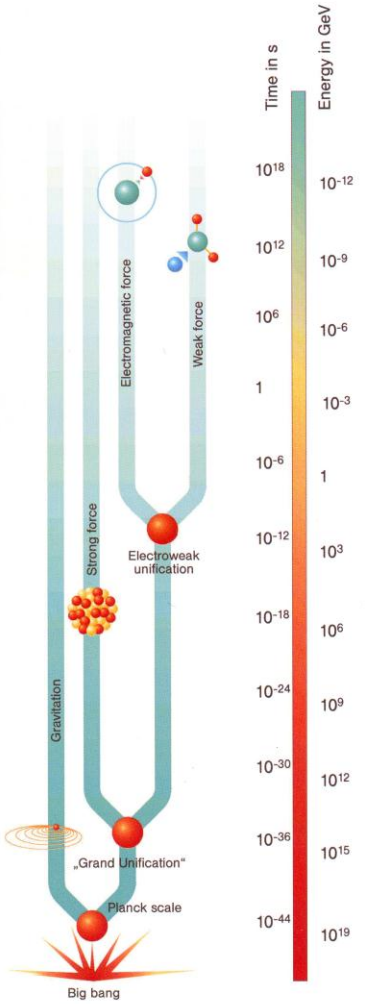
The question of unification

Is there a universal force, a common origin of the different interactions ?

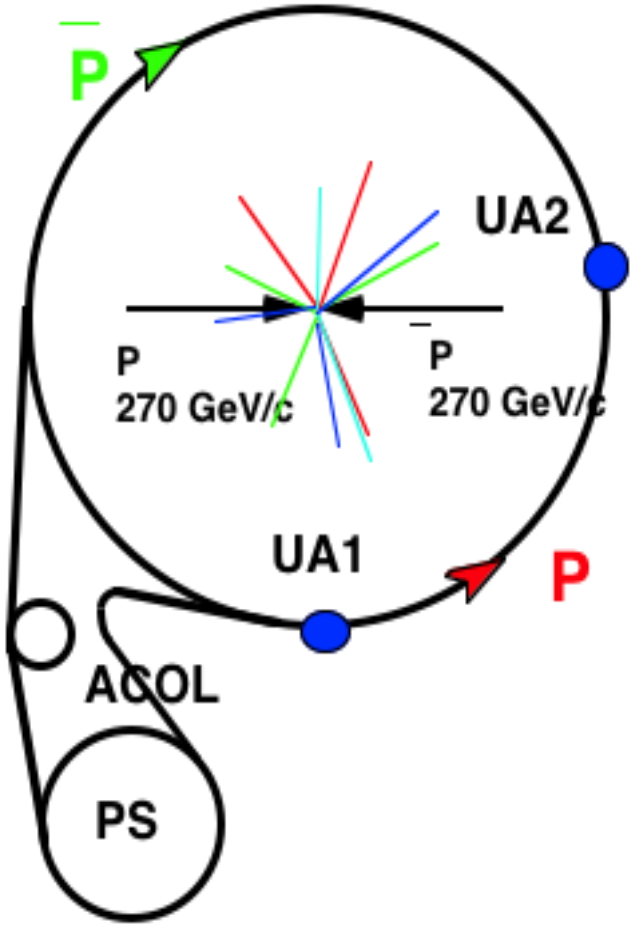
Famous example: J.C.Maxwell (1864)
Unification of electricity and magnetism

1962-1973: Glashow, Salam and Weinberg

Unification of the electromagnetic and weak interactions
⇒ electroweak interaction
(prediction of W- und Z-bosons)
Higgs mechanism is a cornerstone of the model



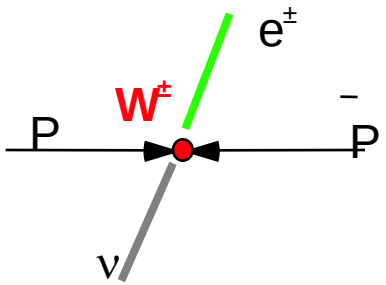
One step in the chain

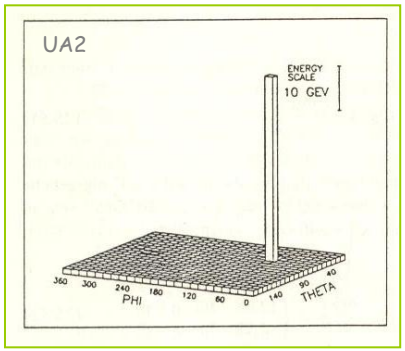


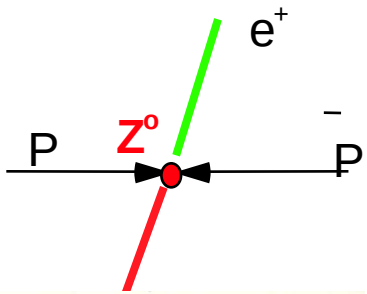
CERN - early 80s

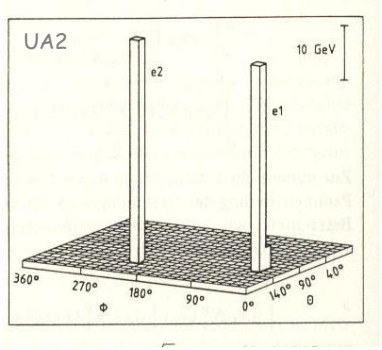
Discovery of the Intermediate Vector Bosons

W/Z at the UA1 and UA2 experiments (1983-84)









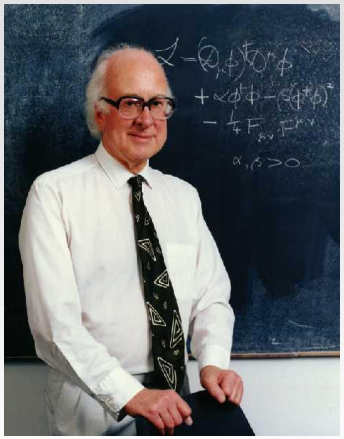
Beautiful confirmation of the ElectroWeak Theory (Standard Model)

Carlo RUBBIA and Simon VAN DER MEER

Higgs: the search is a must!

"Revealing the physical mechanism that is responsible for the breaking of the electroweak symmetry is one of the key problems in particle physics"

"A new collider, such as the LHC must have the potential to detect this particle should it exist"



Prof. Peter Higgs

The Higgs could be anywhere up to *~1 TeV*
… or even nowhere!

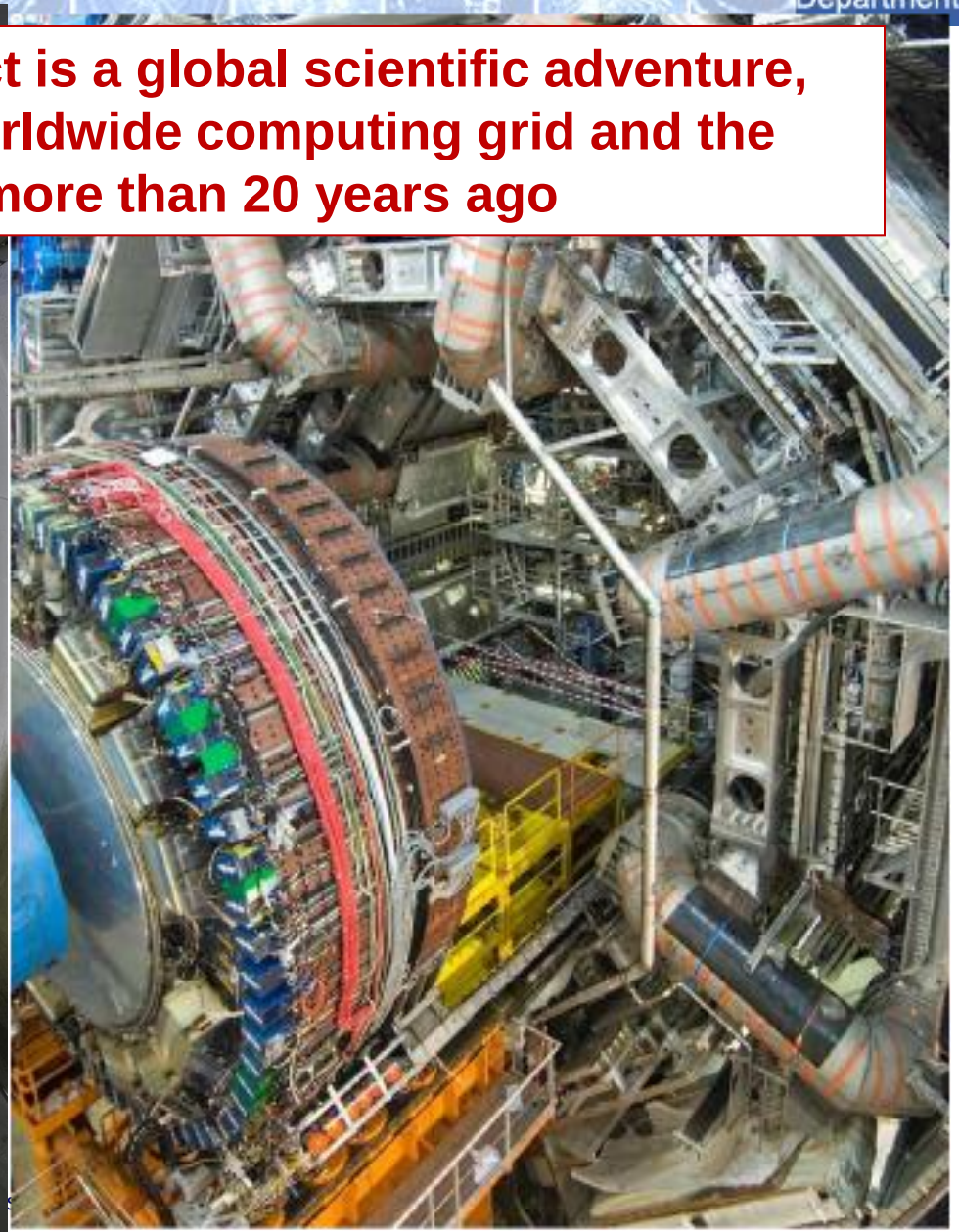
Higgs or no Higgs
at ~1 Tev "something" must happen!

weakly interacting particles will interact strongly
Supersymmetry
Technicolor
…

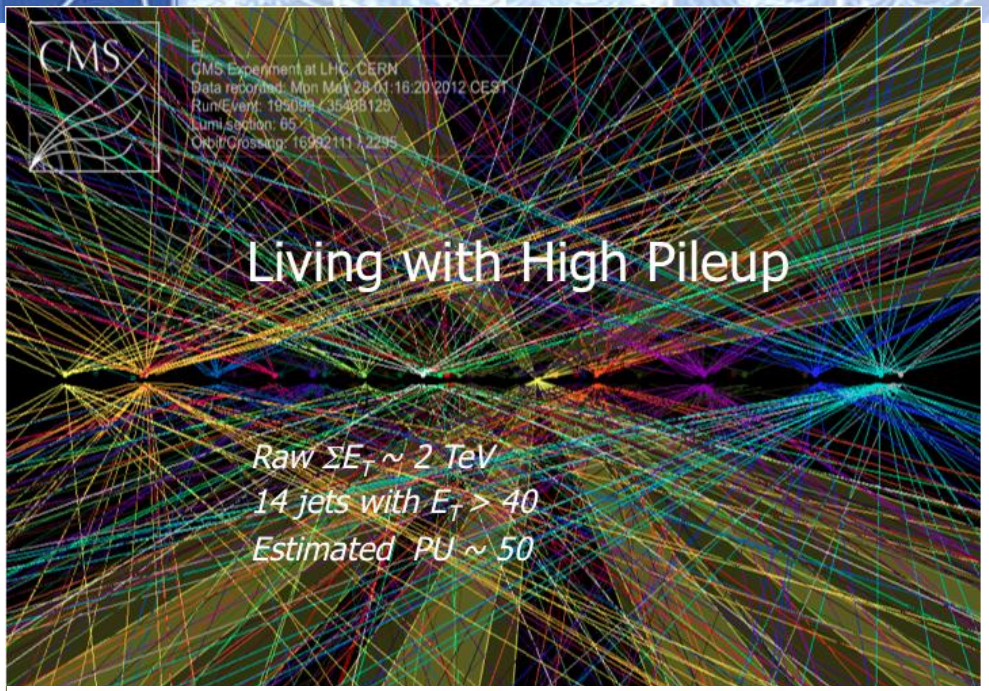
There is a strong physics motivation, from many viewpoints, to explore at the 1TeV energy scale

The Large Hadron Collider LHC

The Large Hadron Collider project is a global scientific adventure, combining the accelerator, a worldwide computing grid and the experiments, initiated more than 20 years ago



New experimental challenge

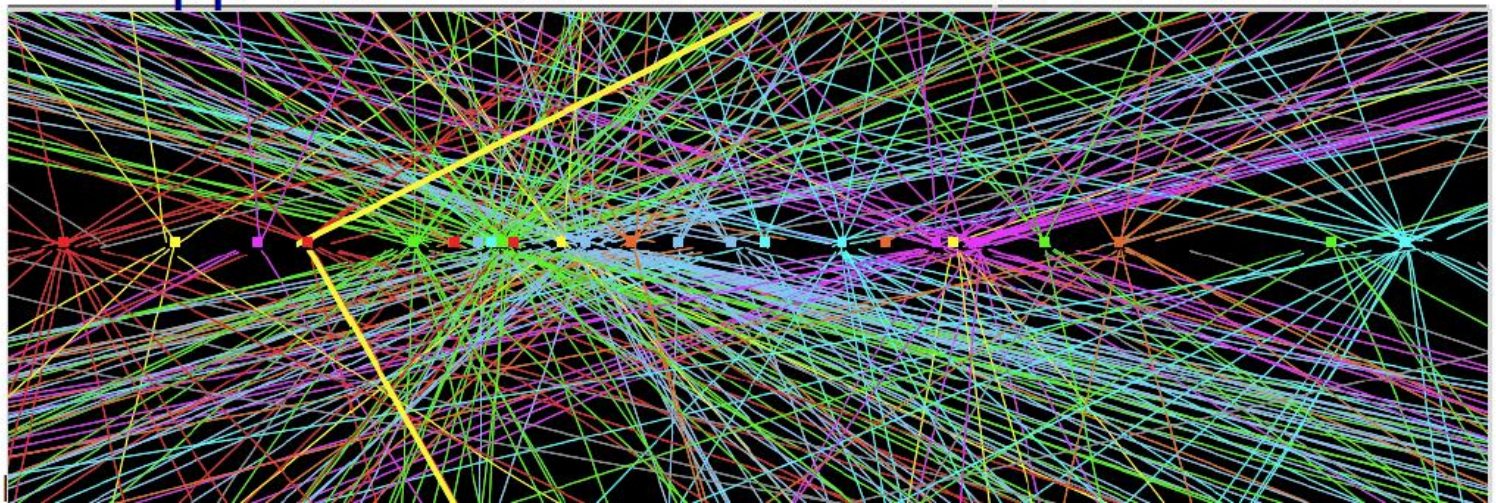


7×10^8 interactions/s
2×10^7 bunch crossings/s

↓

At peak L, pileup of 35 events !

Z→μμ event from 2012 data with 25 vertices



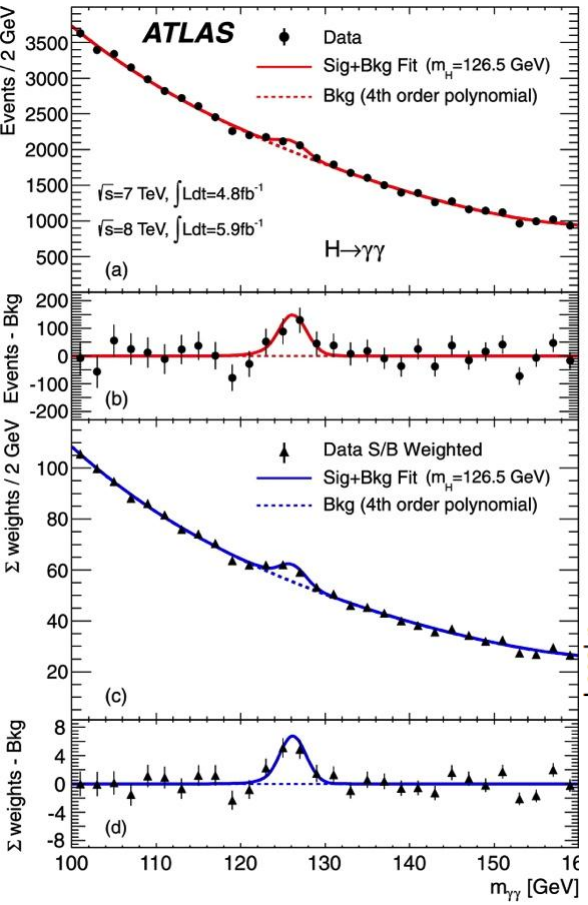
$H \rightarrow \gamma\gamma$

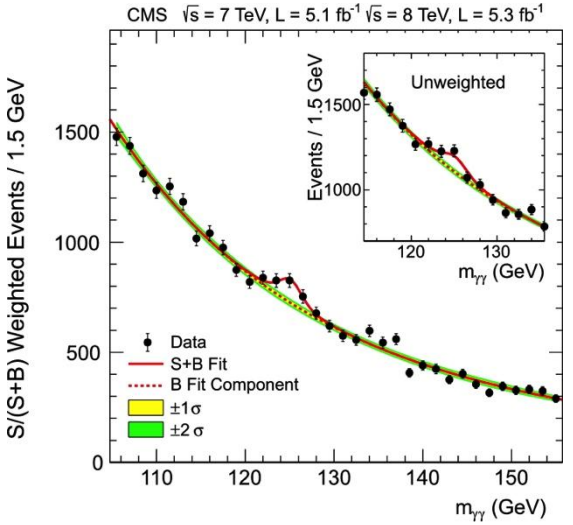
Events are split into categories depending on expected S/B.

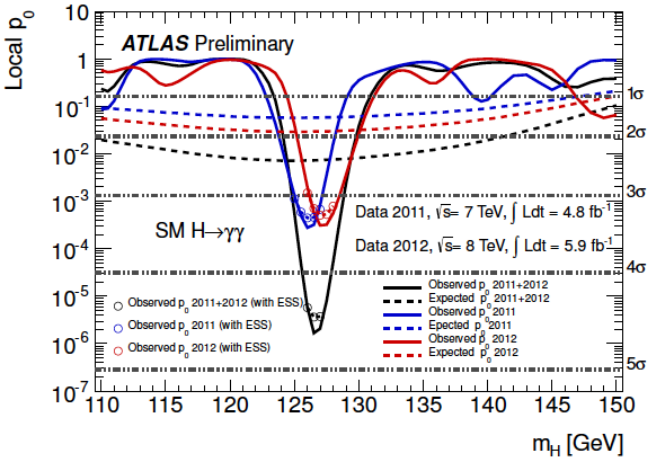
Plots with S/B weighting represent better the statistical analysis

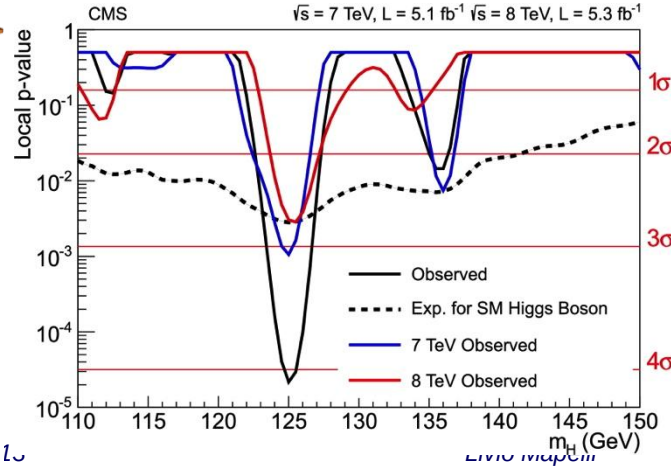
ATLAS:
m_H = 126.5 GeV (min p0)
Local sig 4.5 σ
Exp significance 2.4 σ

CMS:
m_H = 125 GeV (min p0)
Local sig 4.1 σ
Exp significance 2.8 σ

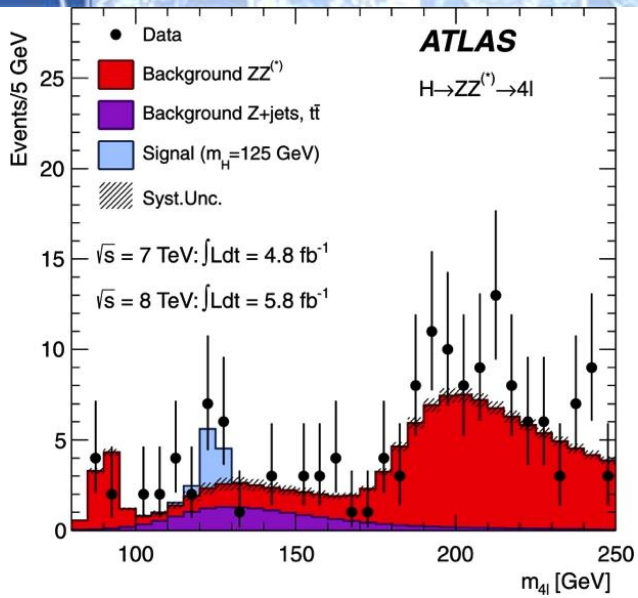






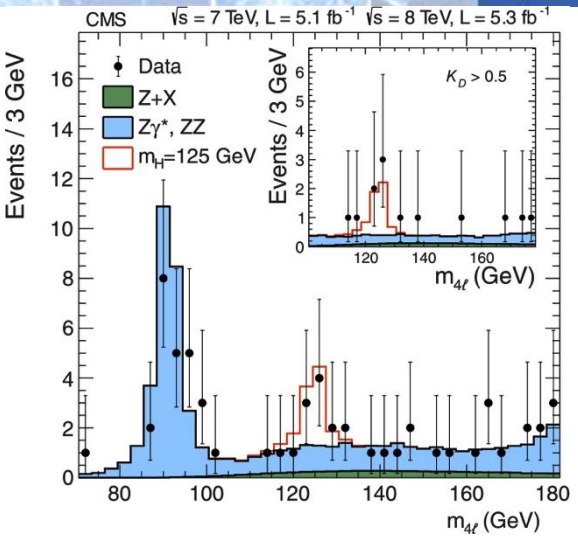


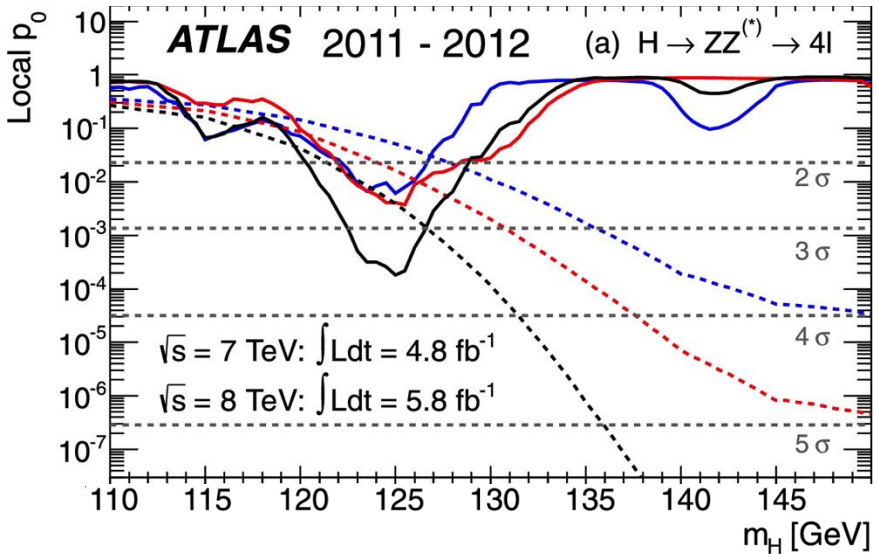
$H \rightarrow ZZ^* \rightarrow 4\ \text{leptons}(e, \mu)$

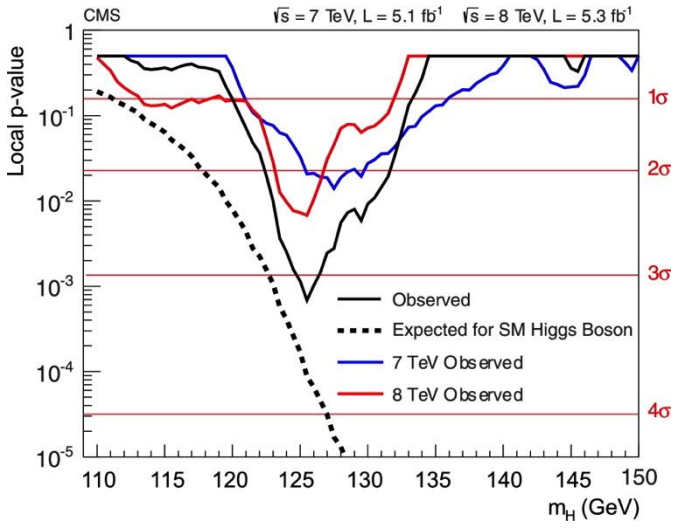


ATLAS:
m_H = 125 GeV (min p0)
Local sig 3.4 σ
Exp significance 2.6 σ

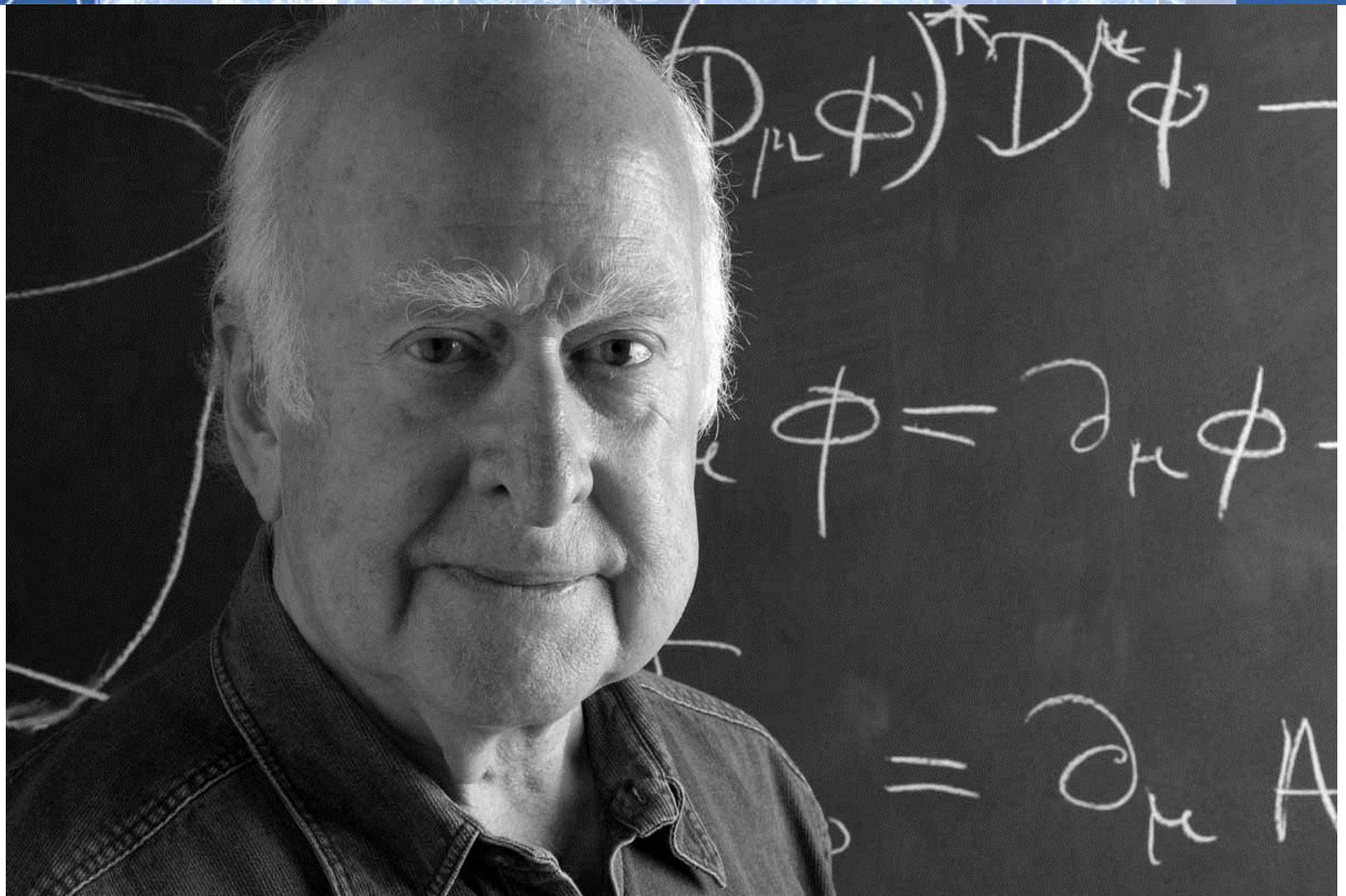
CMS:
m_H = 125.6 GeV (min p0)
Local sig 3.2 σ
Exp significance 3.8 σ







Peter HIGGS



Is this new particle the Higgs boson?

- It looks like it… but it is too early to tell
- We will need to measure its properties in the months to come
- Even if it is the Higgs boson, this is only the beginning, as this particle raises many other questions

Will this particle change our day-to-day life? Early to say, but our understanding of the Universe is about to change

Key Questions in Particle Physics

origin of mass/matter or
origin of electroweak symmetry breaking

unification of forces

fundamental symmetry of forces and matter

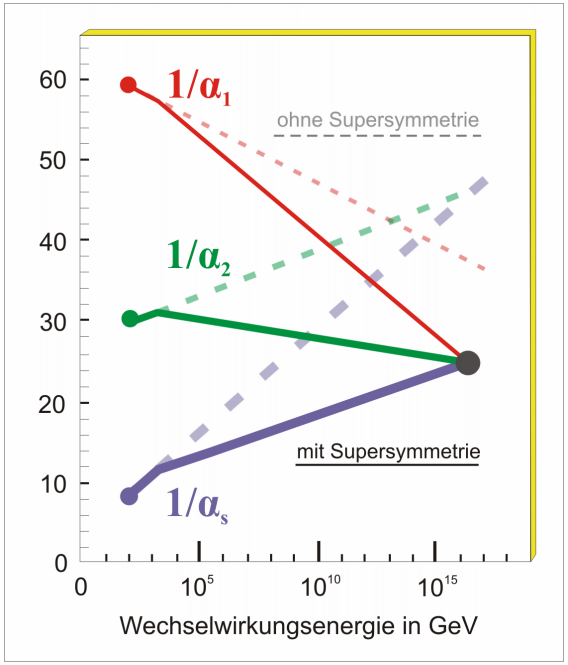
where is antimatter

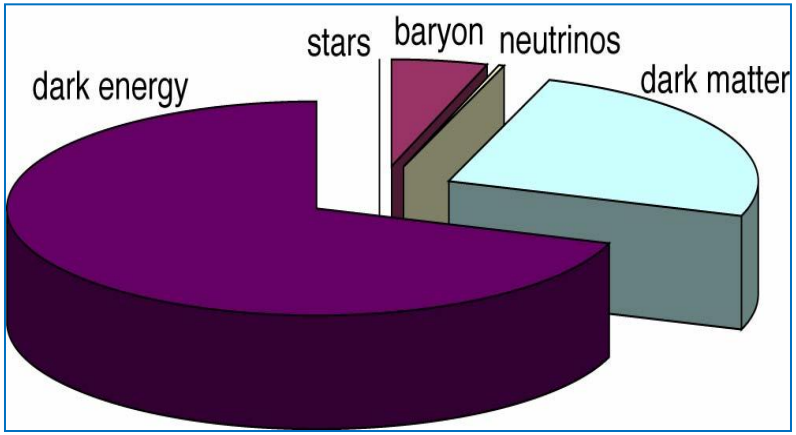
unification of quantum physics and general relativity

number of space/time dimensions

what is dark matter

what is dark energy





SUSY

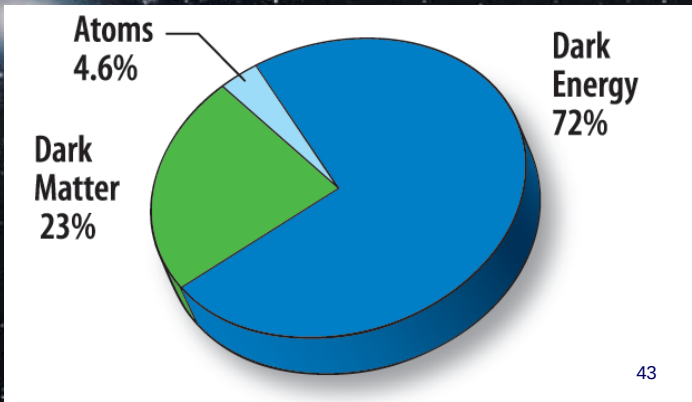
Dark Matter in the Universe

Astronomers found that most of the matter in the Universe must be invisible Dark Matter

Vera Rubin ~ 1970

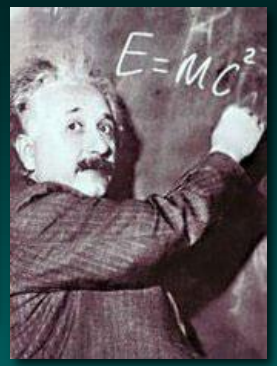
‘Supersymmetric’ particles ?

F. Zwicky 1898-1974



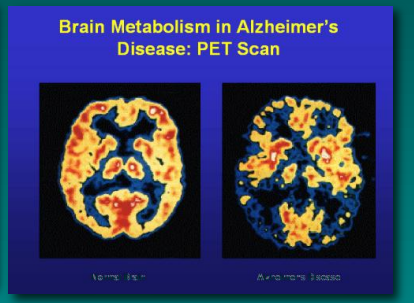
Innovation
Education
CERN
uniting people
Research

The Mission of CERN



- Push back the frontiers of knowledge

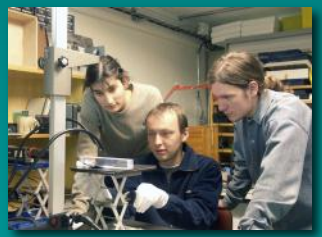
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



- Develop new technologies for accelerators and detectors

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy



- Train scientists and engineers of tomorrow

CERN Education Activities

PH Physics Department

Scientists at CERN
Academic Training Programme

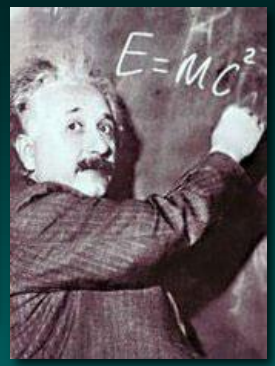
Young Researchers
CERN School of High Energy Physics
CERN School of Computing
CERN Accelerator School

Physics Students
Summer Students Programme

CERN Teacher Schools
International and National Programmes

Innovation
Education
CERN
uniting people
Research

The Mission of CERN



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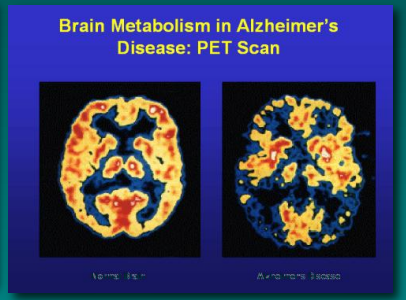

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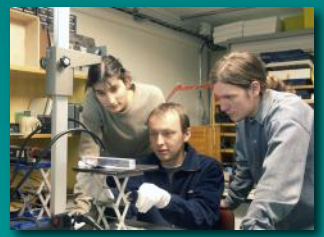


- Train scientists and engineers of tomorrow

- Unite people from different countries and cultures

CERN was founded 1954: 12 European States

"Science for Peace"

- The largest particle physics lab in the world
- Over 50 years of scientific excellence
- 13,000 people united in a common effort
- Including > 3000 students
- Hundreds of high-school teachers every year

- ~ 2300 staff
- ~ 1050 other paid personnel
- > 11000 users
- Budget (2012) 830 MEUR

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

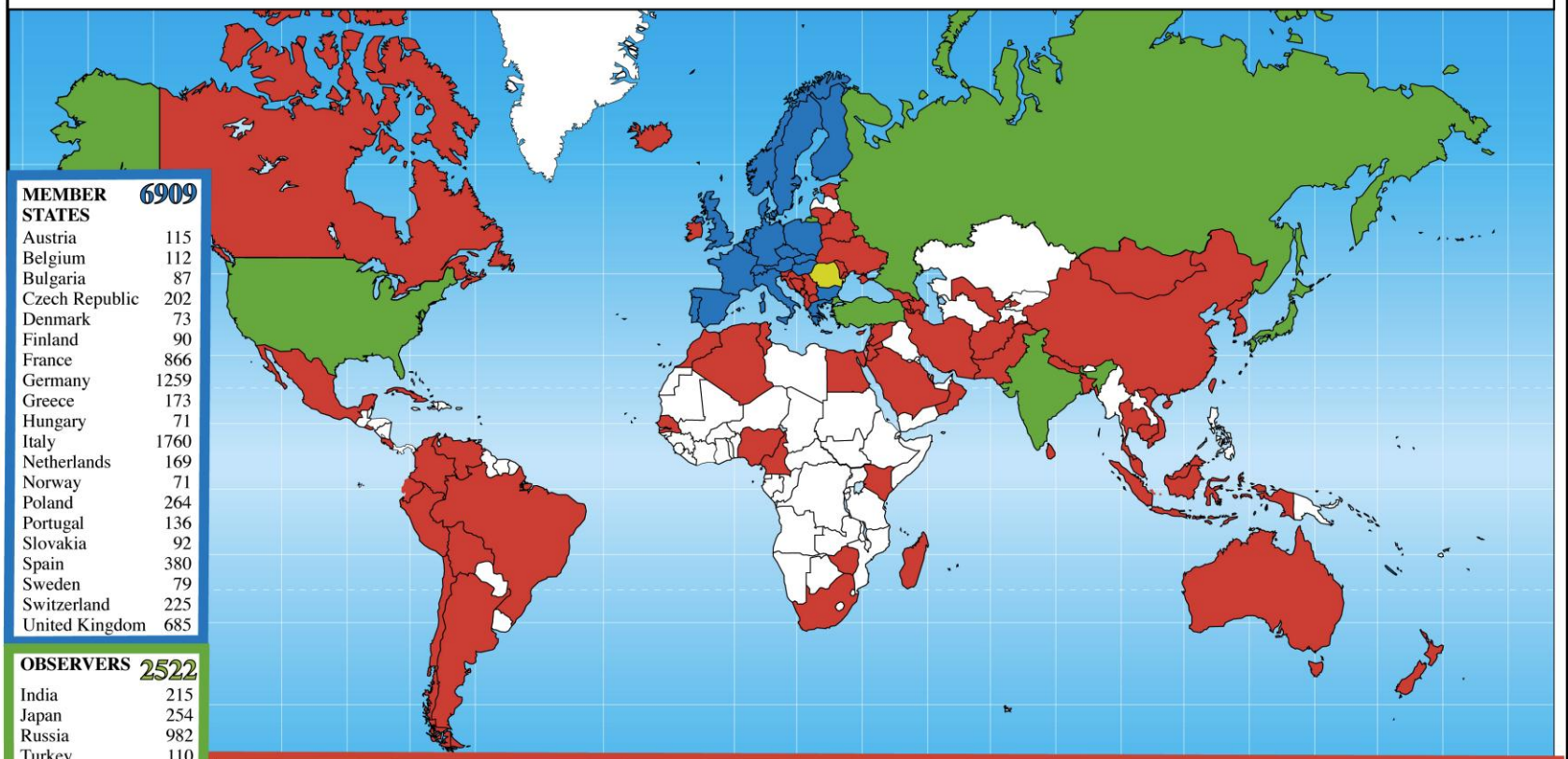
Associate Members in the Pre-Stage to Membership: Israel, Serbia

Applicant States: Cyprus, Slovenia, Turkey

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

Science is getting more and more global

Distribution of All CERN Users by Nationality on 4 April 2012



MEMBER STATES	6909
Austria	115
Belgium	112
Bulgaria	87
Czech Republic	202
Denmark	73
Finland	90
France	866
Germany	1259
Greece	173
Hungary	71
Italy	1760
Netherlands	169
Norway	71
Poland	264
Portugal	136
Slovakia	92
Spain	380
Sweden	79
Switzerland	225
United Kingdom	685

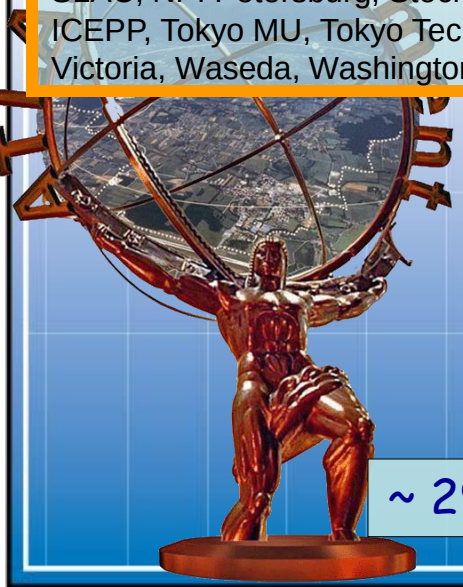
OBSERVERS	2522
India	215
Japan	254
Russia	982
Turkey	110
USA	961

CANDIDATE FOR ACCESSION	
Romania	117

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP	
Israel	67
Serbia	39

OTHERS													
Afghanistan	1	Bosnia & Herzegovina	2	Cuba	6	Ireland	23	Mexico	63	Peru	5	Tunisia	6
Albania	3	Brazil	98	Cyprus	14	Jordan	2	Moldova	1	Qatar	1	Ukraine	46
Algeria	11	Cambodia	1	Ecuador	2	Kenya	1	Mongolia	1	San Marino	1	Uzbekistan	2
Argentina	16	Cameroon	2	Egypt	9	Korea, D.P.R.	1	Montenegro	2	Saudi Arabia	3	Venezuela	10
Armenia	21	Canada	141	El Salvador	1	Korea Rep.	119	Morocco	13	Senegal	1	Viet Nam	10
Australia	23	Chile	6	Estonia	15	Lebanon	11	Nepal	3	Slovenia	43	Zimbabwe	2
Azerbaijan	6	China	270	Georgia	31	Lithuania	17	New Zealand	8	South Africa	16		
Bangladesh	2	China (Tapei)	48	Hong Kong	1	Luxembourg	3	Nigeria	1	Sri Lanka	6		
Belarus	41	Colombia	29	Iceland	4	Madagascar	3	Oman	1	Syria	1	**1353**	
Bolivia	2	Costa Rica	2	Indonesia	2	Malaysia	7	Pakistan	44	Thailand	7		
		Croatia	30	Iran	21	Malta	2	Palestine (O.T.).	3	T.F.Y.R.O.M.	3		

Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Annecy, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, HU Berlin, Bern, Birmingham, UAN Bogota, Bologna, Bonn, Boston, Brandeis, Brasil Cluster, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, CERN, Chinese Cluster, Chicago, Chile, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, AGH UST Cracow, IFJ PAN Cracow, SMU Dallas, UT Dallas, DESY, Dortmund, TU Dresden, JINR Dubna, Duke, Edinburgh, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, Göttingen, LPSC Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Iowa, UC Irvine, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, UN La Plata, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, CPPM Marseille, Massachusetts, MIT, Melbourne, Michigan, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, McGill Montreal, RUPHE Morocco, FIAN Moscow, ITEP Moscow, MEPhI Moscow, MSU Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Nagoya, Naples, New Mexico, New York, Nijmegen, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Olomouc, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Regina, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, Sussex, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Tokyo Tech, Toronto, TRIUMF, Tsukuba, Tufts, Udine/ICTP, Uppsala, UI Urbana, Valencia, UBC Vancouver, Victoria, Waseda, Washington, Weizmann Rehovot, FH Wiener Neustadt, Wisconsin, Wuppertal, Würzburg, Yale, Yerevan



ATLAS Collaboration

~ 2900 scientists (~1000 students), 172 Institutions, 37 countries

How Do We Manage This?

Contrary to popular belief, our community is rather elementary:

- It has simple rules, honed by centuries of practice
- It shares a common vision and a common set of values
- It is based on collaboration AND competition

Science is intrinsically **not democratic** (can't decide who is right by vote!) and therefore it has to be performed **with the most democratic tools:**

- Freedom of expression
- Peer reviewing
- Independency from political orientation, religion, social status, etc…

The scientists

Despite the usual cinematographic representation, in general we DO NOT

- Wear white lab coats
- Live in ivory towers
- Find a revolutionary result every second day (scientist=genius)
- … And we are not only men!

We are a pragmatic community capable to address in a very material way grand and (apparently) immaterial questions, knowing that for every answer we might find, we will open more and unpredicted questions.

(we definitely prefer to be Ministers of Doubt than Kings of Truth: ubi dubium, ibi libertas)

How can you manage such a community?

Need individualized, enabling structures within supporting infrastructure to:

- Allow everybody to keep his/her 5% of dream (i.e. the own original contribution to the advancement of Science), while operating in a very large symphony orchestra.
- Encourage the emergence of gifted performers/soloists
- Foster a leadership based on credibility and consensus more than on authority

And the Future?

- The relationship between basic research and sustainable progress is fundamental (contrary to common belief, technology does not sustain itself on the long term)
- In a globalized world, **knowledge** is becoming the most important asset.
- Developed countries are about to make a major strategic error by cutting funding for fundamental research (whereas emerging countries are doing the opposite and catching up fast)

Trading future against “futures”.

Is this the right way to go?

THANK YOU!

The predictable future: LHC Time-line

2009 — Start of LHC

Run 1: 7-8 TeV centre of mass energy, luminosity ramping up to 7 10^{33} cm^{-2} s^{-1},~20 fb^{-1} delivered

2013/14 — LHC shut-down to prepare machine for design energy and nominal luminosity

Run 2: Ramp up luminosity to nominal (10^{34} cm^{-2} s^{-1}), ~50 to 60 fb^{-1}

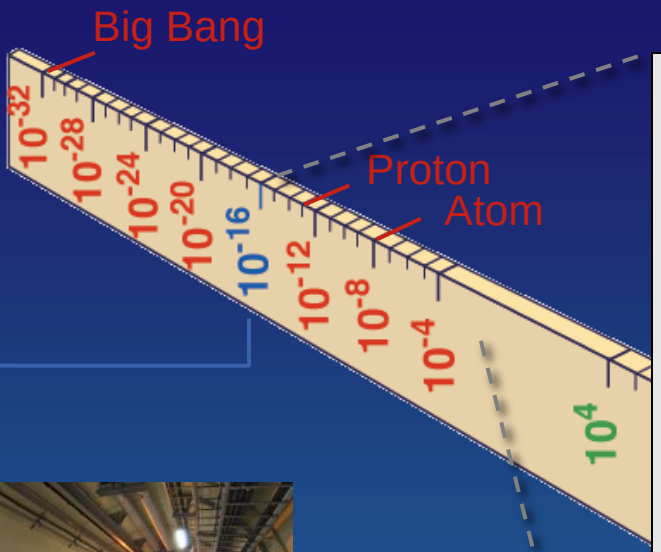
2018 — Injector and LHC Phase-I upgrades to go to ultimate luminosity

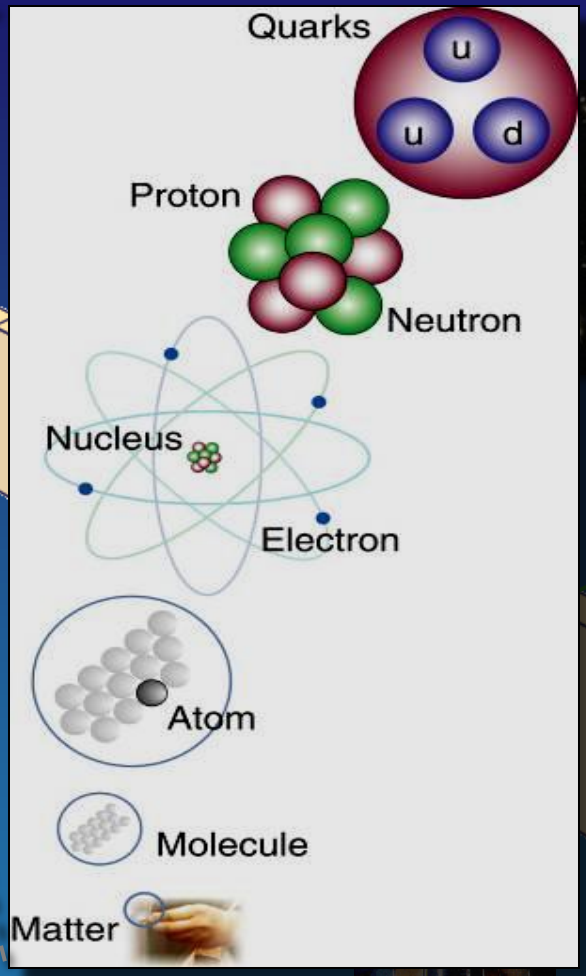
Run 3: Ramp up luminosity to 2.2 x nominal, reaching ~100 fb^{-1} / year accumulate few hundred fb^{-1}

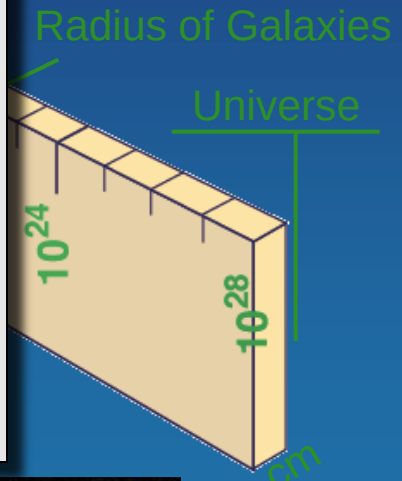
~2022 — Phase-II: High-luminosity LHC. New focussing magnets and CRAB cavities for very high luminosity with levelling

Run 4: Collect data until > 3000 fb^{-1}

2030 — Next machine ?







LHC

Super-Microscope

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