Le boson de Higgs c'est quoi?

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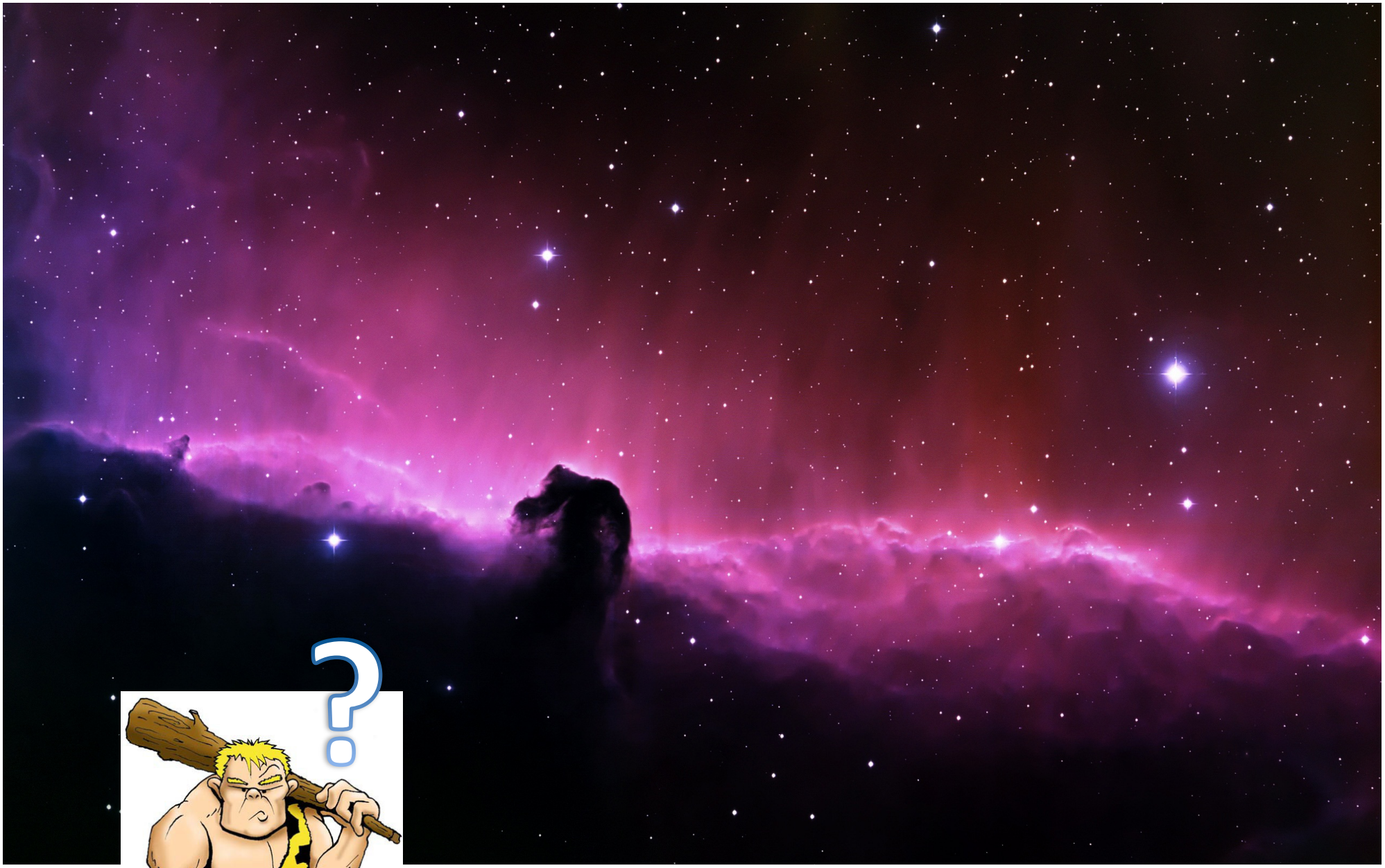
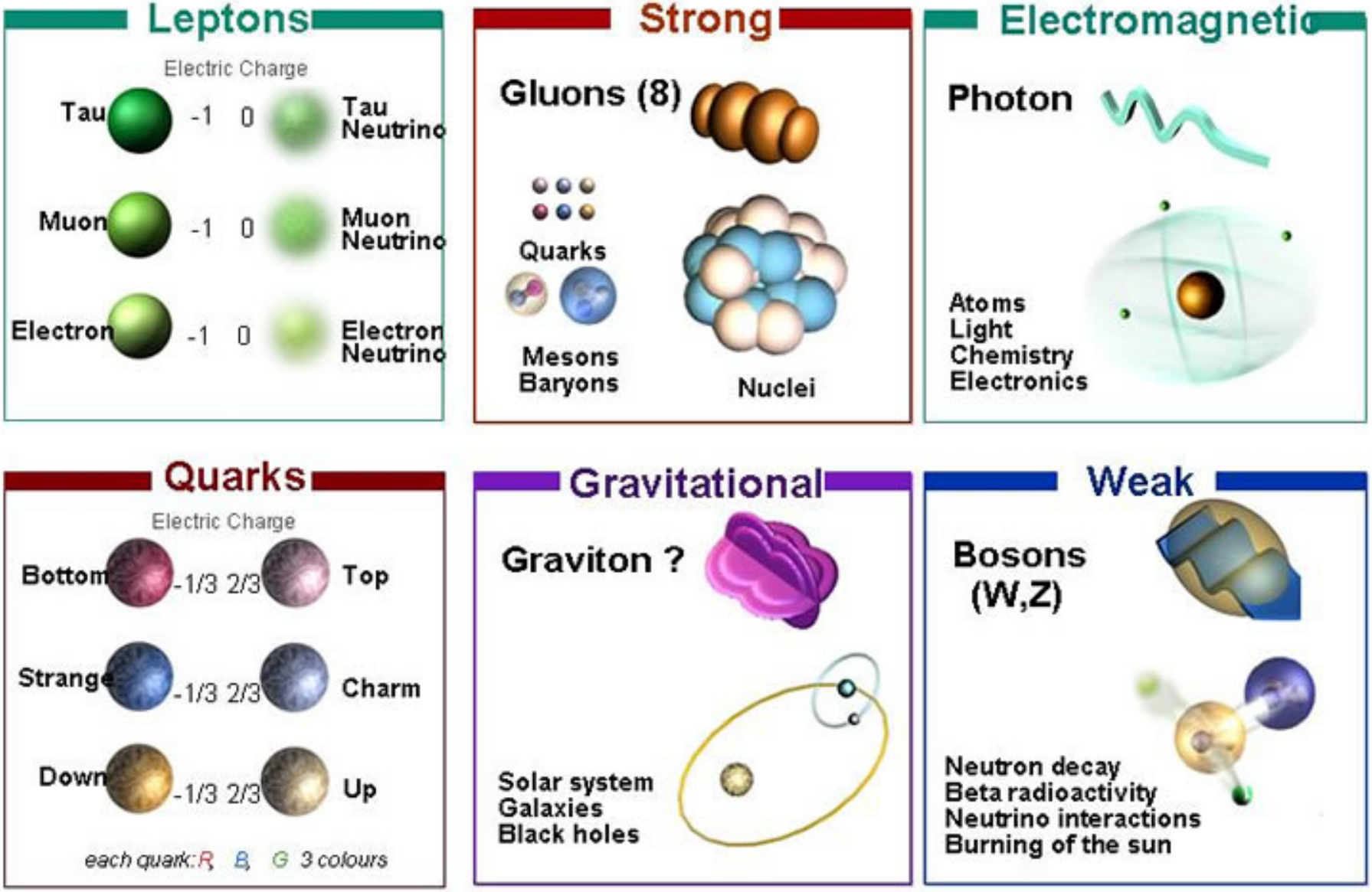
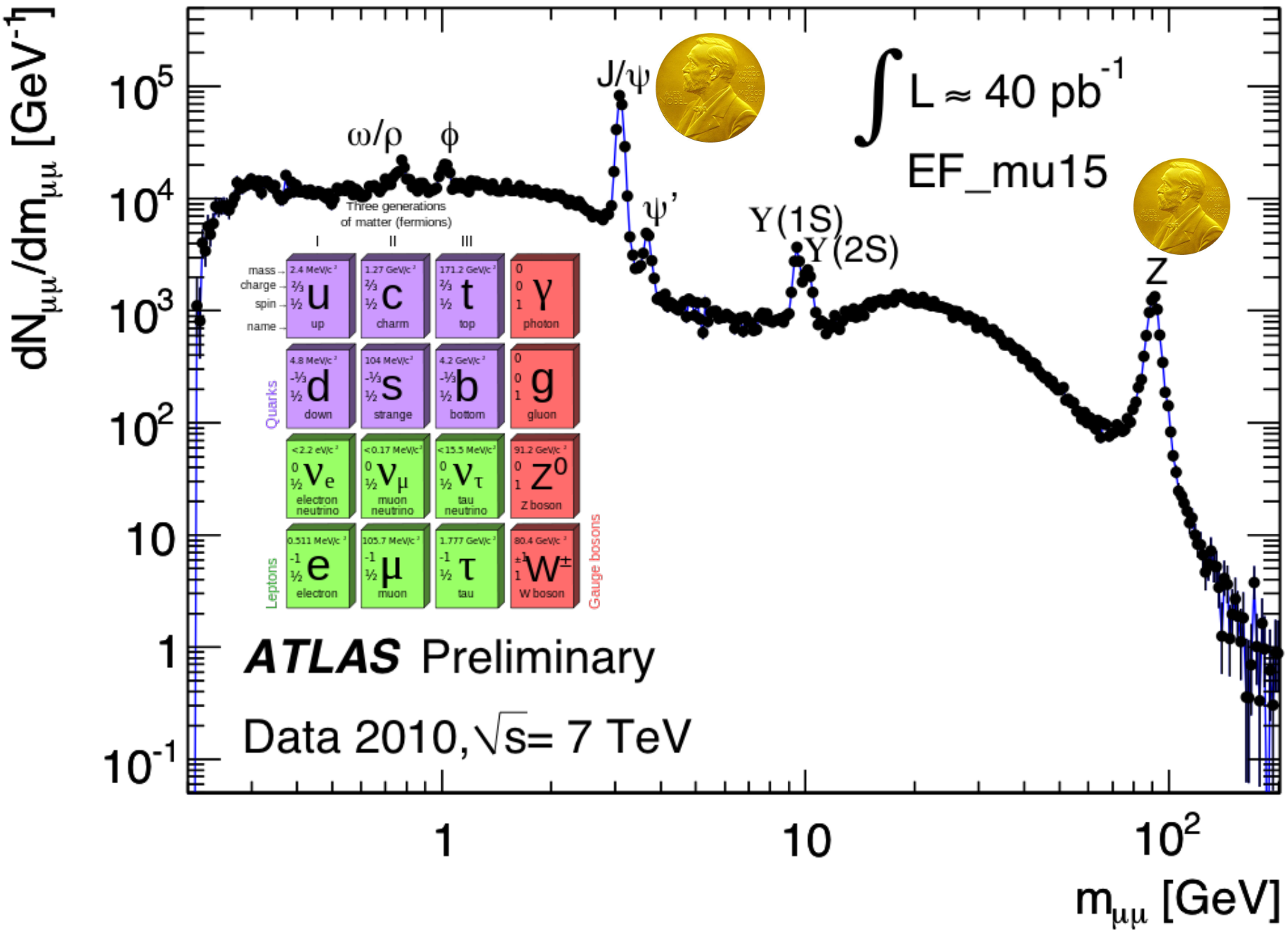
24 Janvier 2013



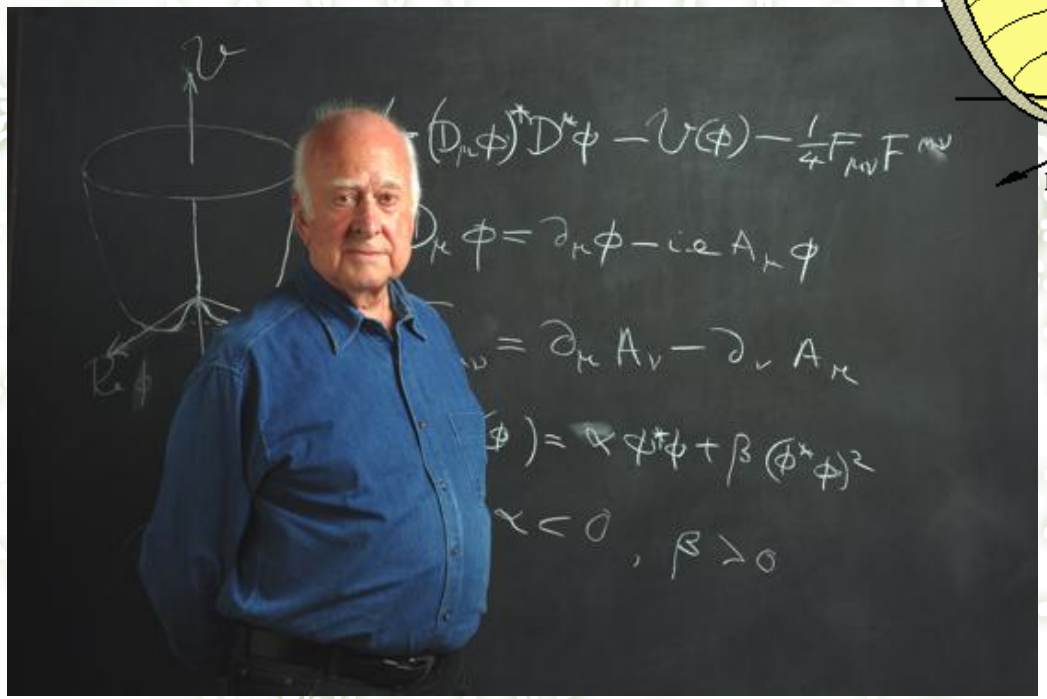
Le Modèle Standard

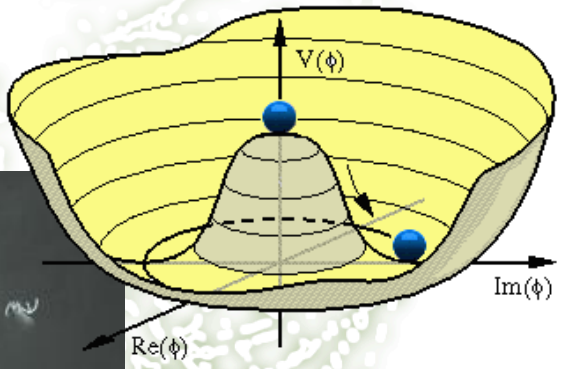



$dN_{\mu\mu}/dm_{\mu\mu}$ [GeV^{-1}]
10^5
10^4
10^3
10^2
10
1
10^{-1}
1
10
10^2
$m_{\mu\mu}$ [GeV]
J/ψ
ω/ρ
φ
ψ'
Υ(1S)
Υ(2S)
Z
$\int L \approx 40$ pb^{-1}
EF_mu15
Three generations of matter (fermions)
I
II
III
mass
charge
spin
name
2.4 MeV/c² ⅔ ½ u up
1.27 GeV/c² ⅔ ½ c charm
171.2 GeV/c² ⅔ ½ t top
0 0 1 γ photon
Quarks
4.8 MeV/c² -⅓ ½ d down
104 MeV/c² -⅓ ½ s strange
4.2 GeV/c² -⅓ ½ b bottom
0 0 1 g gluon
<2.2 eV/c² 0 ½ ν_e electron neutrino
<0.17 MeV/c² 0 ½ ν_μ muon neutrino
<15.5 MeV/c² 0 ½ ν_τ tau neutrino
91.2 GeV/c² 0 1 Z^0 Z boson
Leptons
0.511 MeV/c² -1 ½ e electron
105.7 MeV/c² -1 ½ μ muon
1.777 GeV/c² -1 ½ τ tau
80.4 GeV/c² ±1 1 $W^\pm$ W boson
Gauge bosons
ATLAS Preliminary
Data 2010, $\sqrt{s}$= 7 TeV

Pourquoi chercher le boson de Higgs?

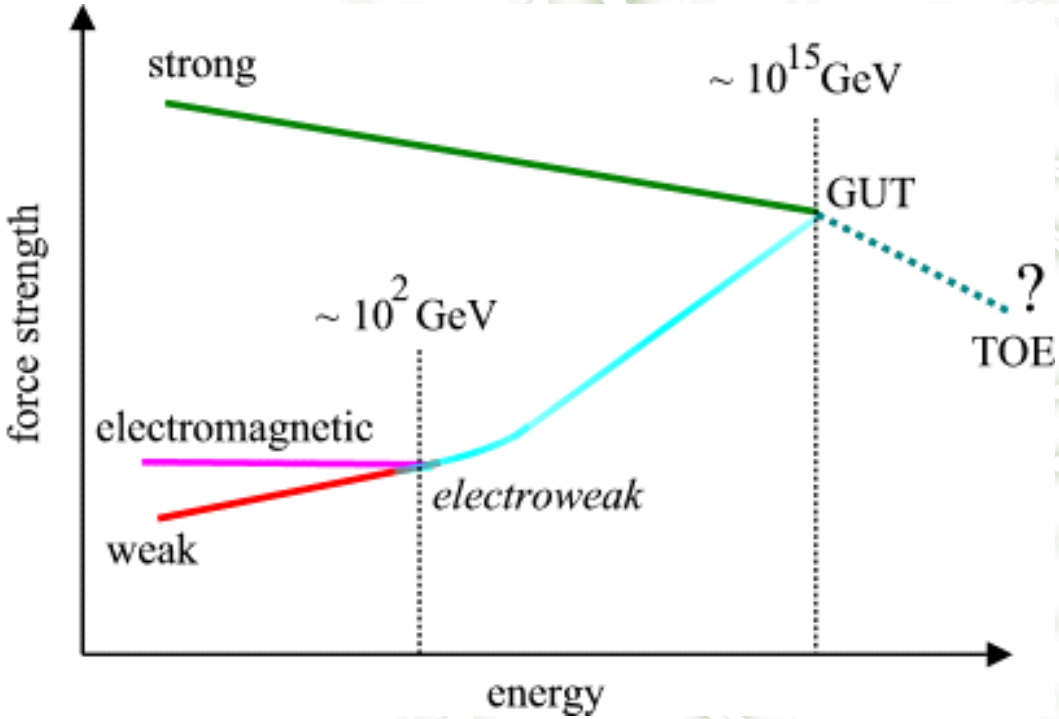
- Le Modèle Standard arrive à décrire l'Univers qu'on connaît (bon, la plupart… on y reviendra)
- Mais il ne fonctionne pas avec des particules fondamentales qui ont de la masse
- Entre le boson de Higgs!

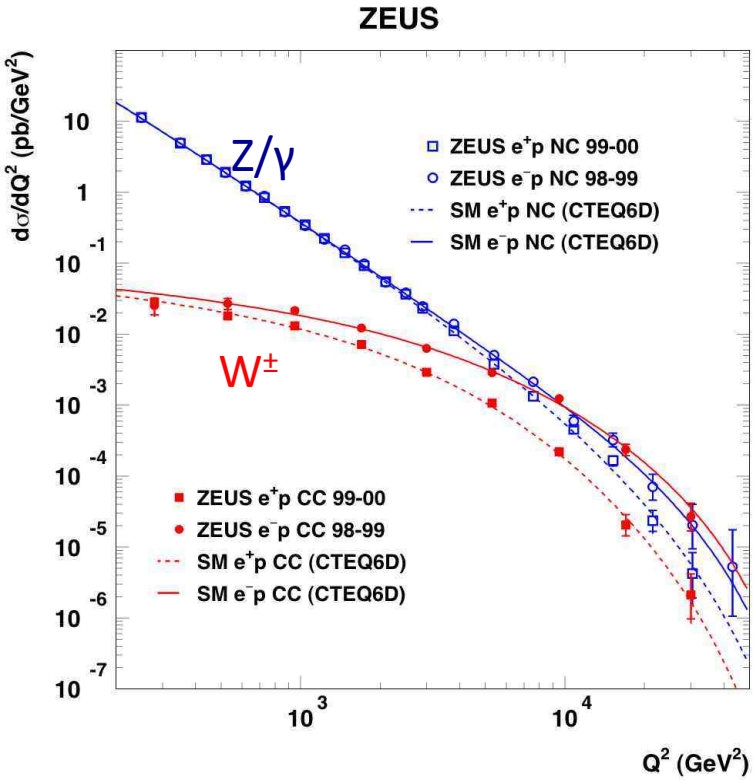


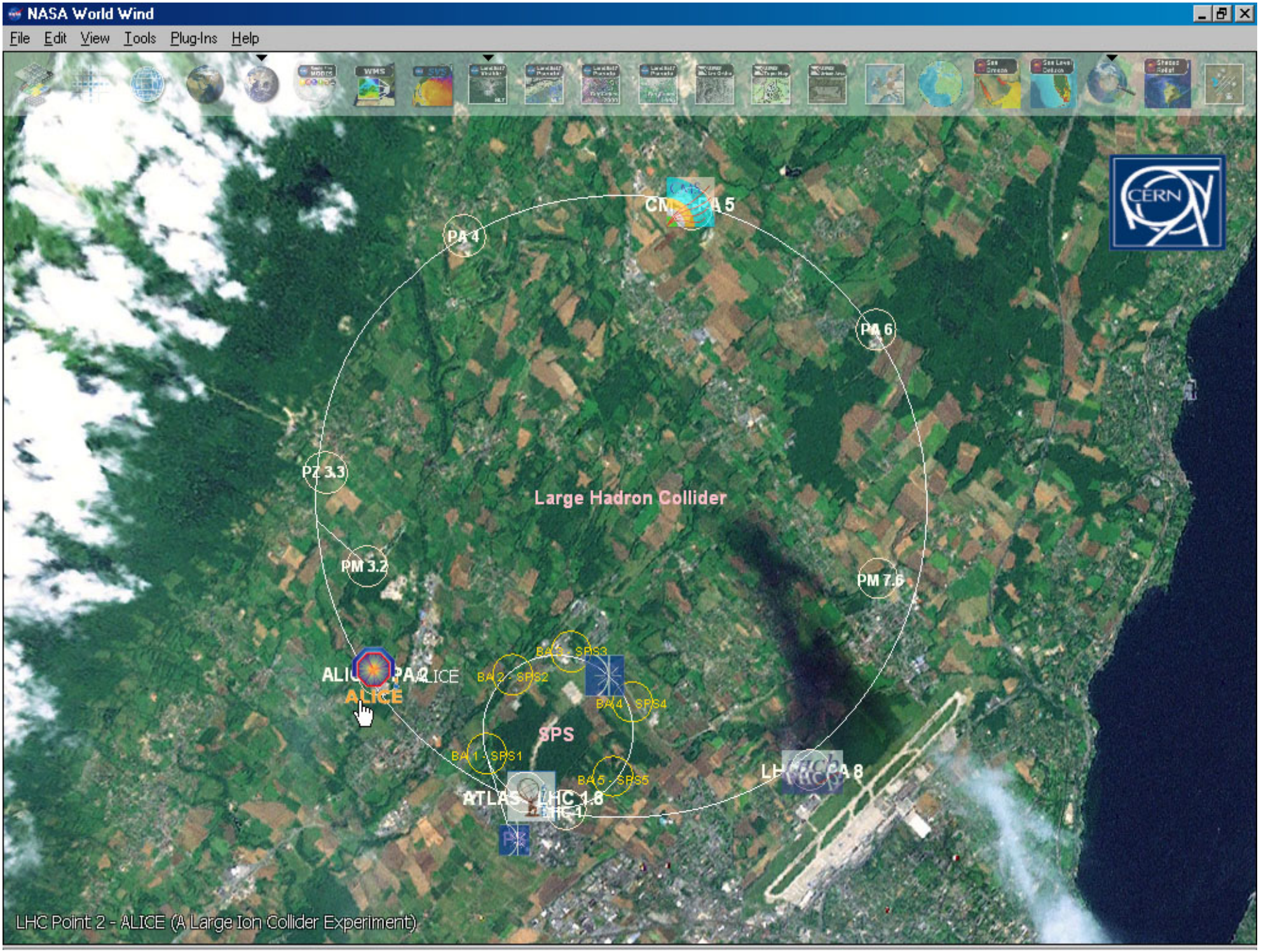


La masse des particules fondamentales

Unification des interactions

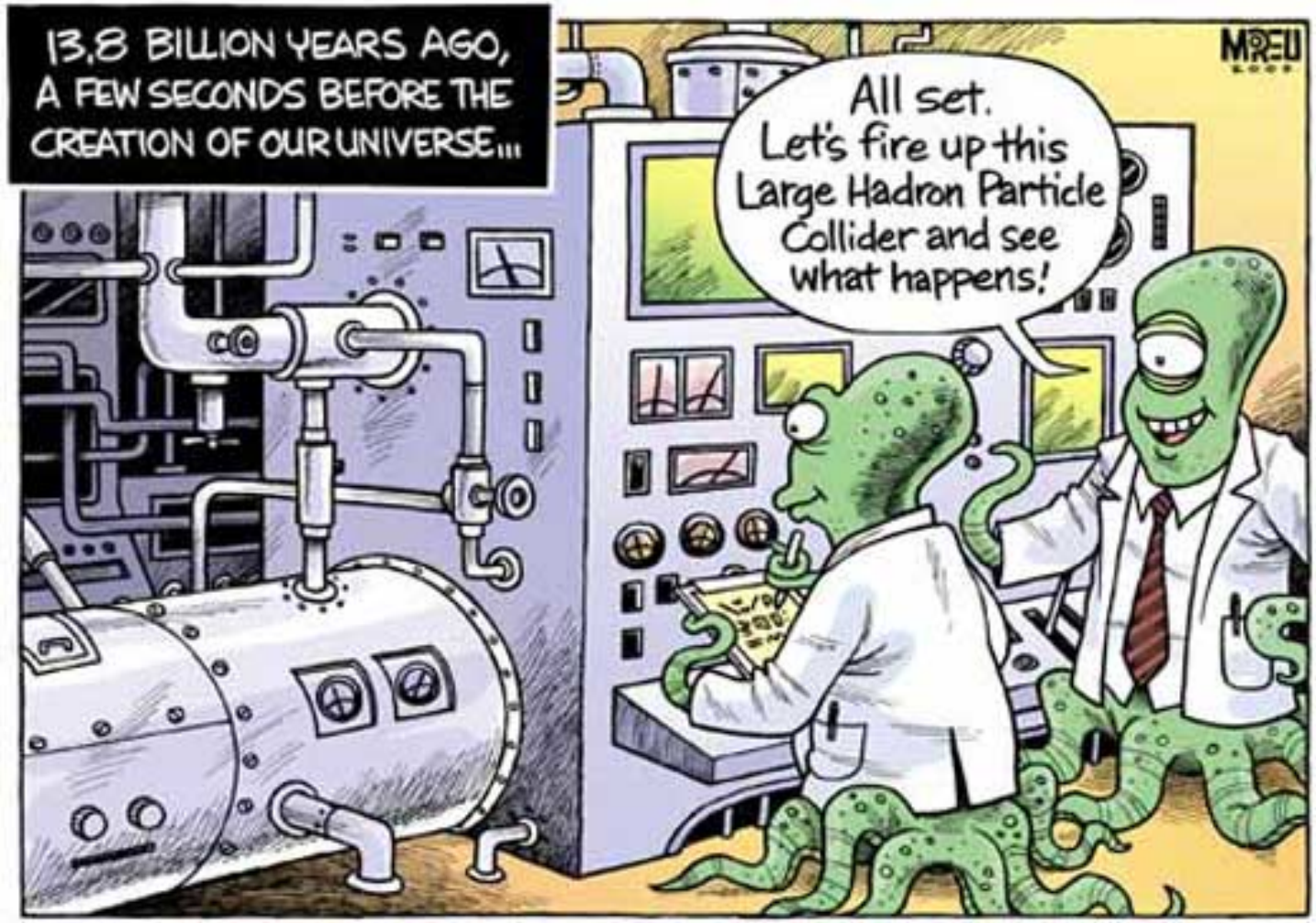


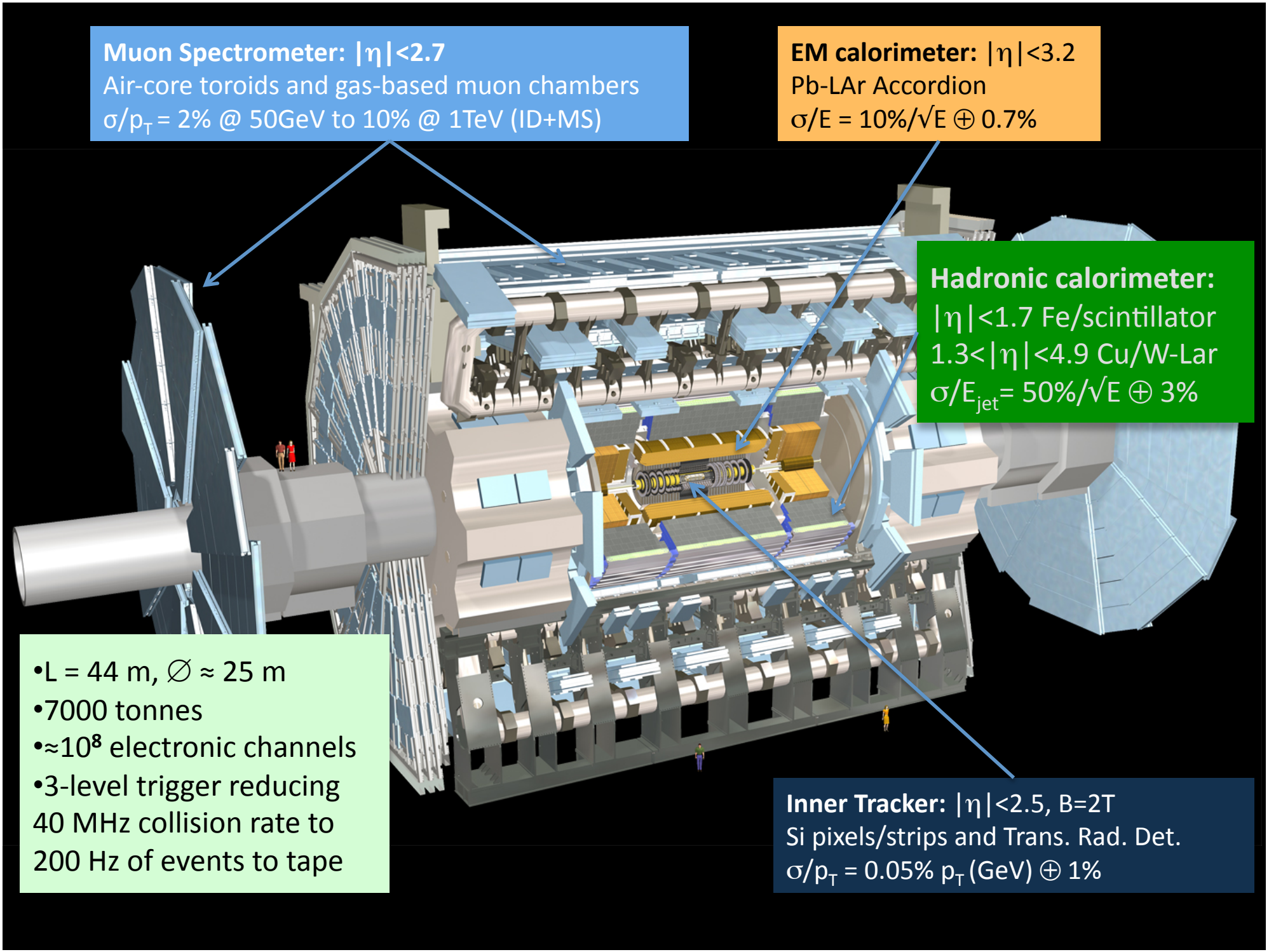


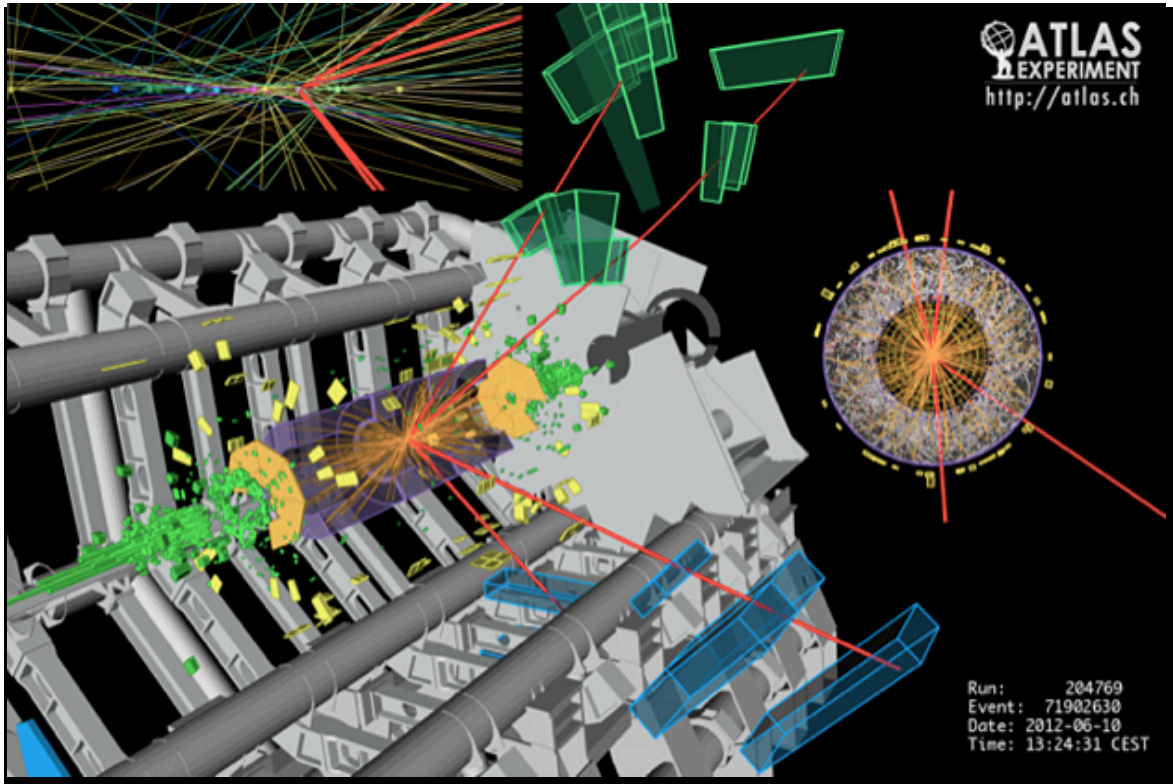

NASA World Wind
File Edit View Tools Plug-Ins Help
CERN
PA 4
PA 6
PZ 3.3
Large Hadron Collider
PM 3.2
PM 7.6
ALICE
BA 2 - SPS2
BA 3 - SPS3
BA 4 - SPS4
SPS
BA 1 - SPS1
BA 5 - SPS5
ATLAS
LHC 1.8
PA 8
LHC Point 2 - ALICE (A Large Ion Collider Experiment)

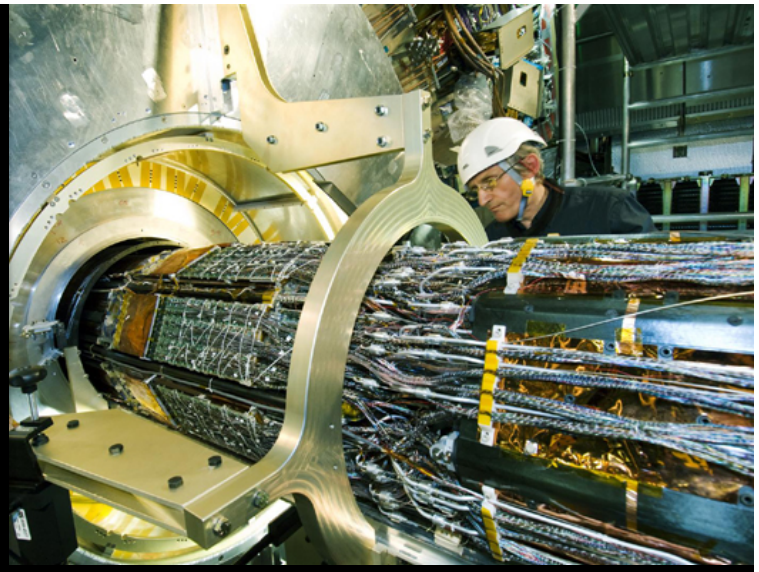
The Large Hadron Collider

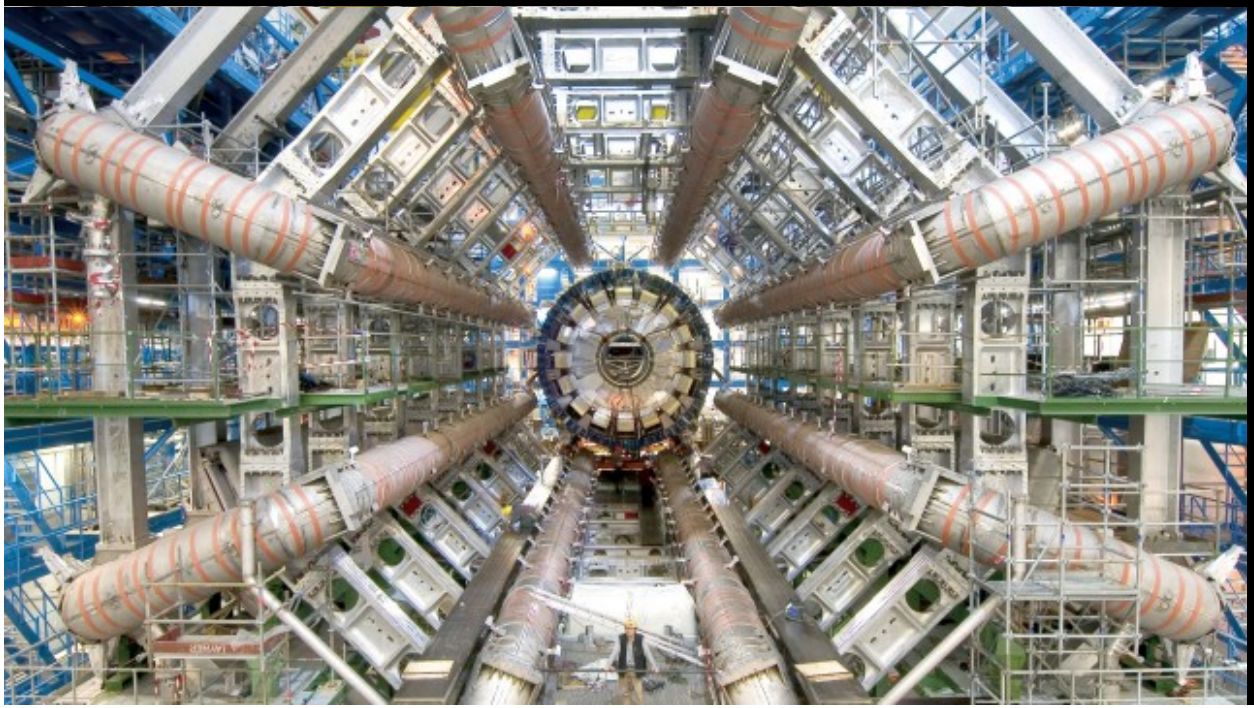
- 26 659m circumference
- 9593 aimants: 1232 dipôles (champ maximum 8T)
- Refroidit à 1.9K (plus froid que l'espace extérieur) avec 120 tonnes d'Helium liquide
- Pression intérieure 10^{-13} atm (10x moins que la lune)
- 50ns entre collisions à 8TeV
- Dans 2 ans: enérgie de collision $\sqrt{s}$ = 14TeV, chaque 25ns (7m à $v = c$)

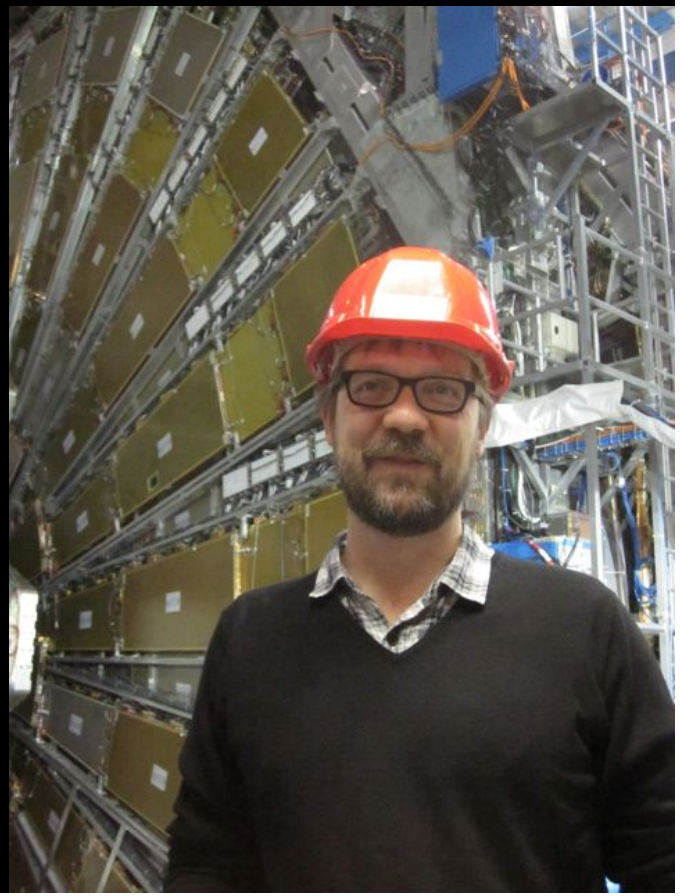

13.8 BILLION YEARS AGO, A FEW SECONDS BEFORE THE CREATION OF OUR UNIVERSE...
All set. Let's fire up this Large Hadron Particle Collider and see what happens!
MORE!


Muon Spectrometer: $|\eta|<2.7$
Air-core toroids and gas-based muon chambers
σ/p_T = 2% @ 50GeV to 10% @ 1TeV (ID+MS)
EM calorimeter: $|\eta|<3.2$
Pb-LAr Accordion
$\sigma/E = 10\%/\sqrt{E} \oplus 0.7\%$
Hadronic calorimeter:
$|\eta|<1.7$ Fe/scintillator
$1.3<|\eta|<4.9$ Cu/W-Lar
$\sigma/E_{jet} = 50\%/\sqrt{E} \oplus 3\%$
•L = 44 m, ∅ ≈ 25 m
•7000 tonnes
•≈10^8 electronic channels
•3-level trigger reducing
40 MHz collision rate to
200 Hz of events to tape
Inner Tracker: $|\eta|<2.5$, B=2T
Si pixels/strips and Trans. Rad. Det.
$\sigma/p_T = 0.05\%\ p_T\,(\text{GeV}) \oplus 1\%$

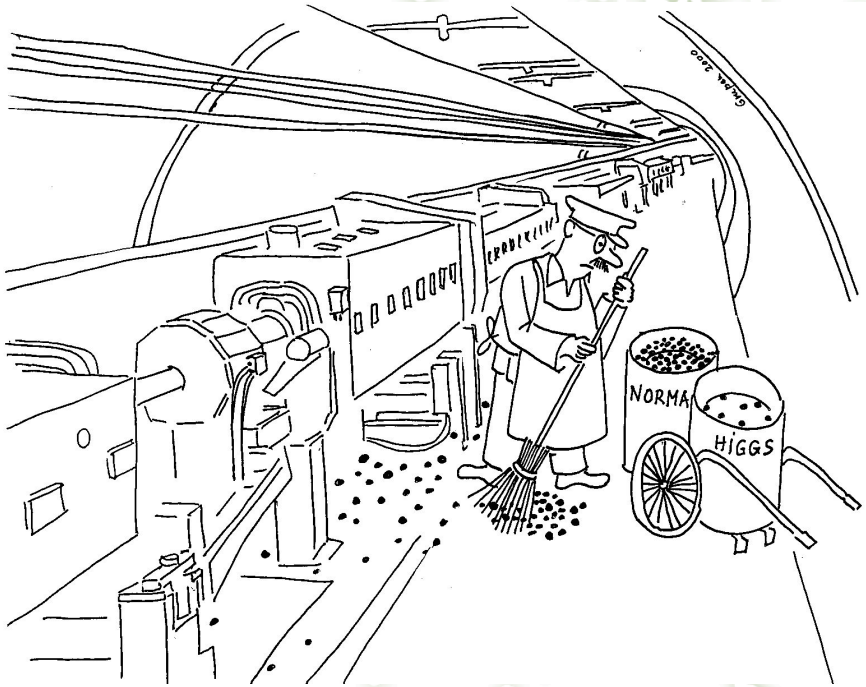

ATLAS
EXPERIMENT
http://atlas.ch
Run: 204769
Event: 71902630
Date: 2012-06-10
Time: 13:24:31 CEST

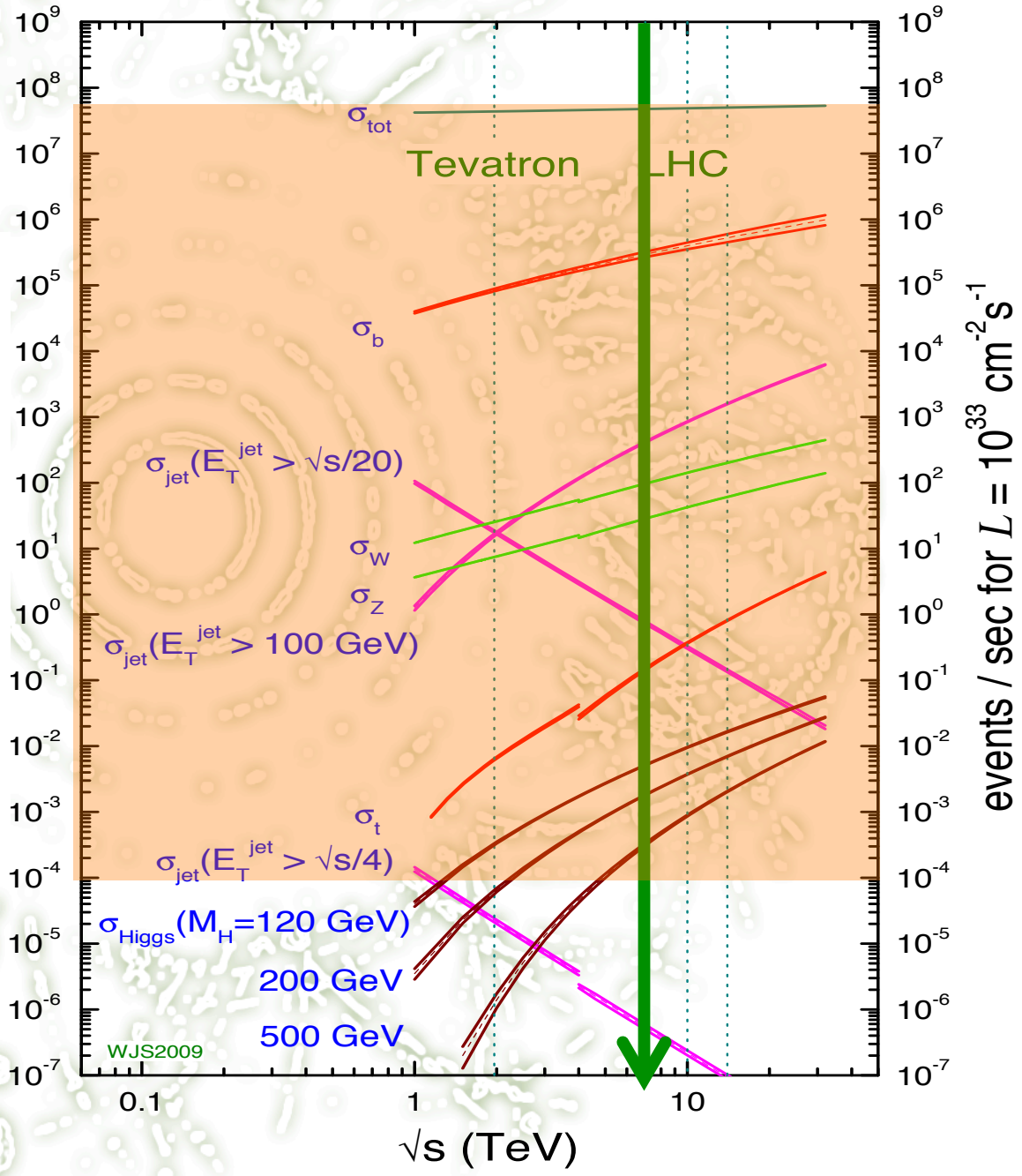




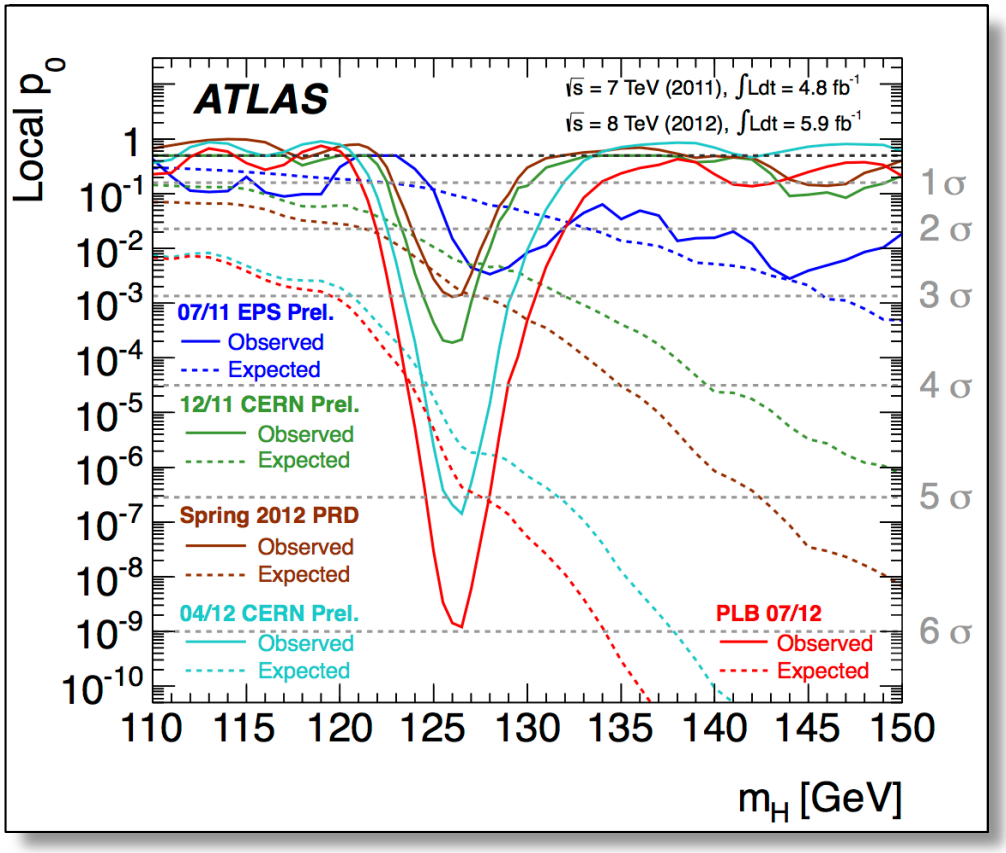


Le bruit de fond dans la recherche du Higgs





La découverte de la nouvelle particule au CERN



News on 04/07/2012

la Repubblica.it

Cern, scoperta la "particella di Dio"

« PRECEDENTE Foto 1 di 19 SUCCESSIVO

Higgs boson-like particle discovery claimed at LHC

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Khoa học

Cỡ chữ : A- A

Sân bóng của các hạt nhân

06/07/2012

Ngày 4.7 tại Geneva, Thụy Sĩ, Viện Nghiên cứu hạt nhân châu Âu (CERN) công bố đã phát hiện ra một loại hạt cơ mới được cho là tương ứng với hạt Higgs - còn gọi là "hạt của Chúa" mà các nhà khoa học đây công tìm kiếm tr 5 thập niên qua. Nếu thông tin này hoàn toàn chính xác, khám phá trên sẽ có tầm ảnh hưởng tương đương với việc Christophe Columbus tìm ra châu Mỹ.

ZEIT ONLINE WISSEN

WISSENSCHAFT

ZARTSEITE PC Gesundheit

Scoperto il Bosone di Higgs la particella di Dio esiste davvero

The New York Times

U.S. | N.Y. / REGION | BUSINESS | TE

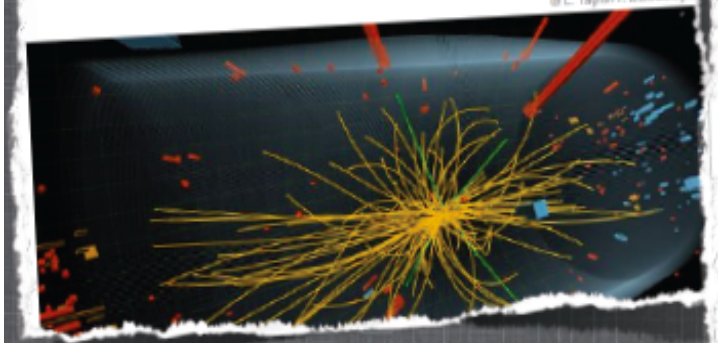
Le boson de Higgs découvert avec 99,9999 % de certitude

Le Monde.fr | 04.07.2012 à 13h39 • Mis à jour le 04.07.2012 à 13h39

PHYSIK

Haarscharf am gottverdammten Teilchen vorbei

Die Belege scheinen überwältigend: Forscher könnten ein neues Teilchen gefunden haben. Unklar ist, ob es das Higgs-Boson ist, der letzte Baustein im Weltbild der Physik.



Physicists Find Elusive Particle Seen as Key to Universe

Scientists in Geneva on Wednesday applauded the discovery of a

theguardian

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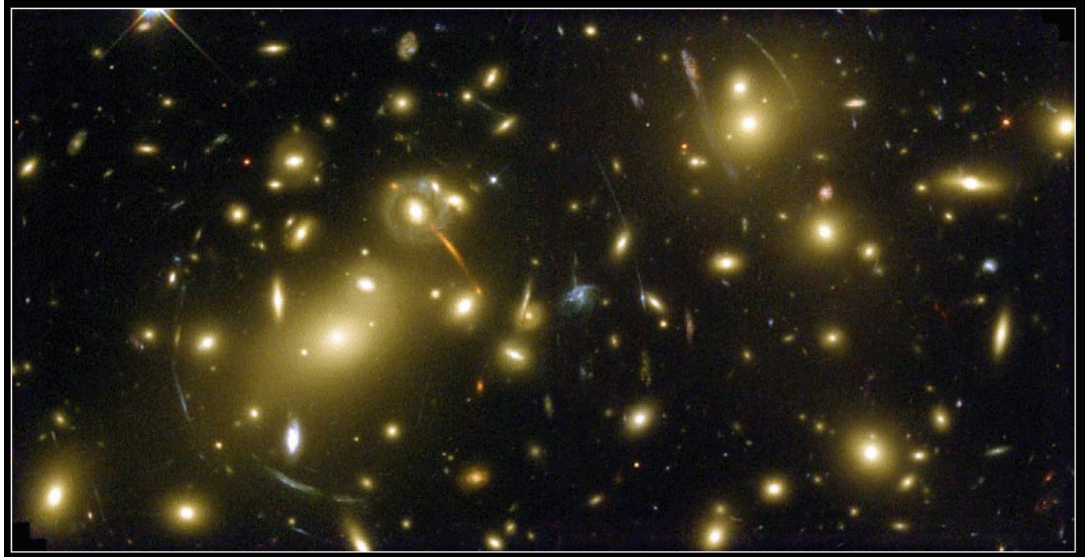
Comment is free

The Higgs boson discovery is another giant leap for humankind

The Cern discovery of the Higgs particle is up there with putting man on the moon – something all humanity can be proud of

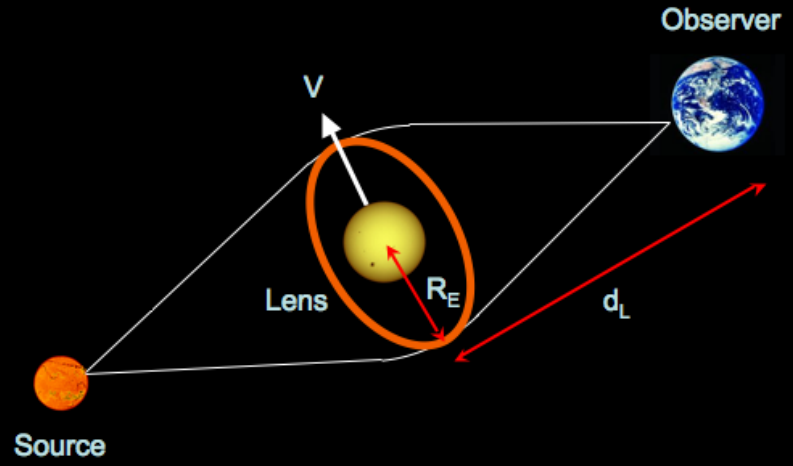

Est’ce le
vrai boson
de Higgs??

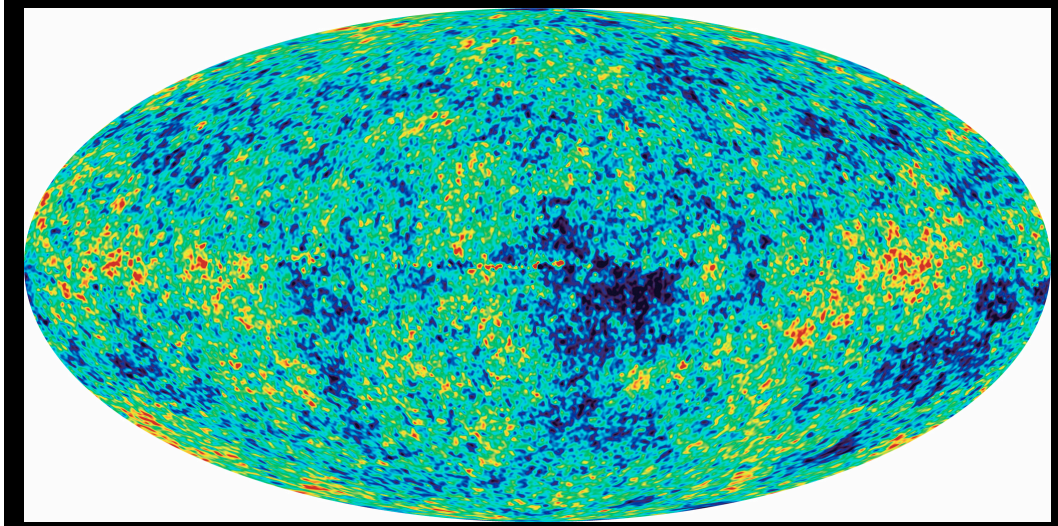
Juste le début!

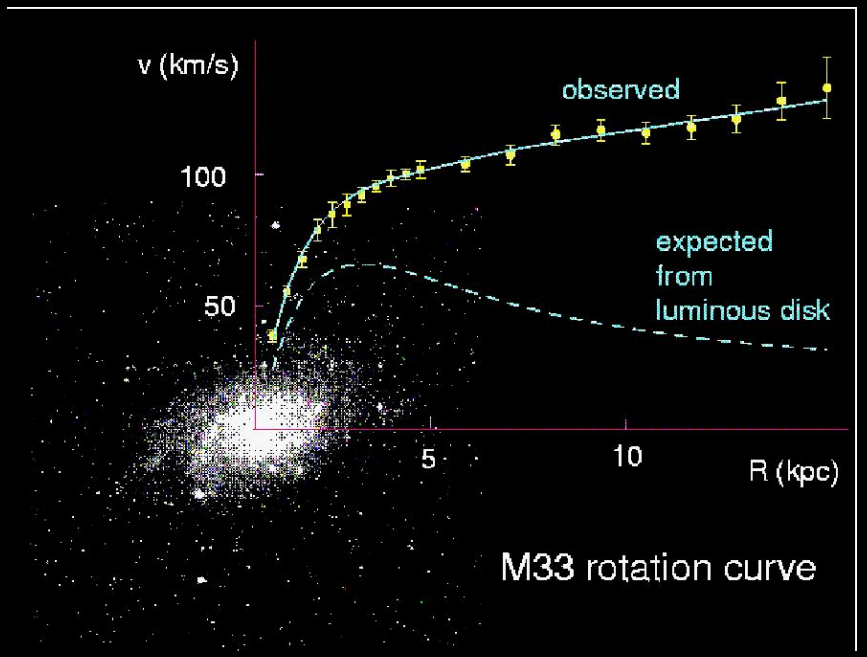


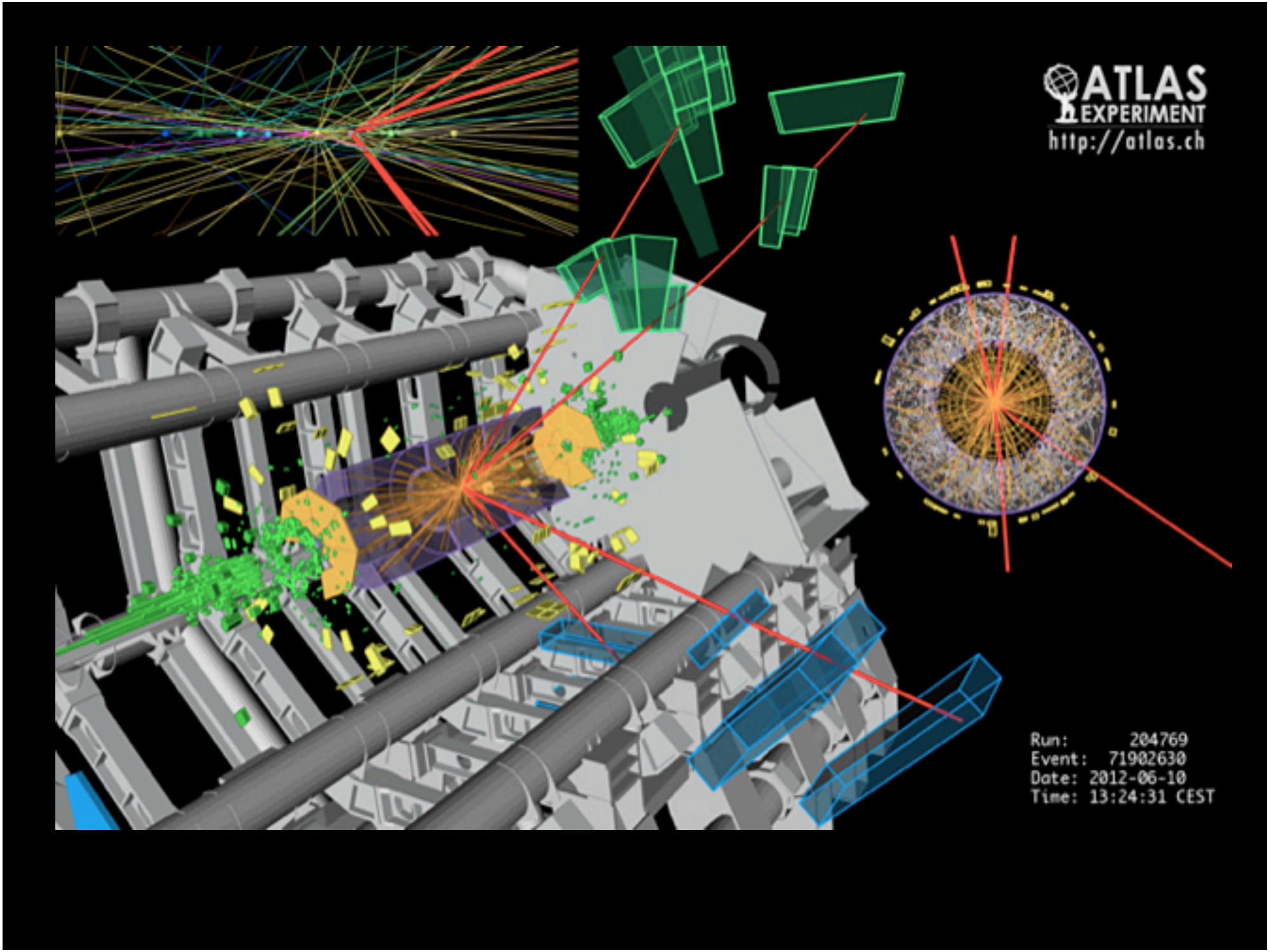
Galaxy Cluster Abell 2218 **HST** • WFPC2

NASA, A. Fruchter and the ERO Team (STScI, ST-ECF) • STScI-PRC00-08





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http://atlas.ch
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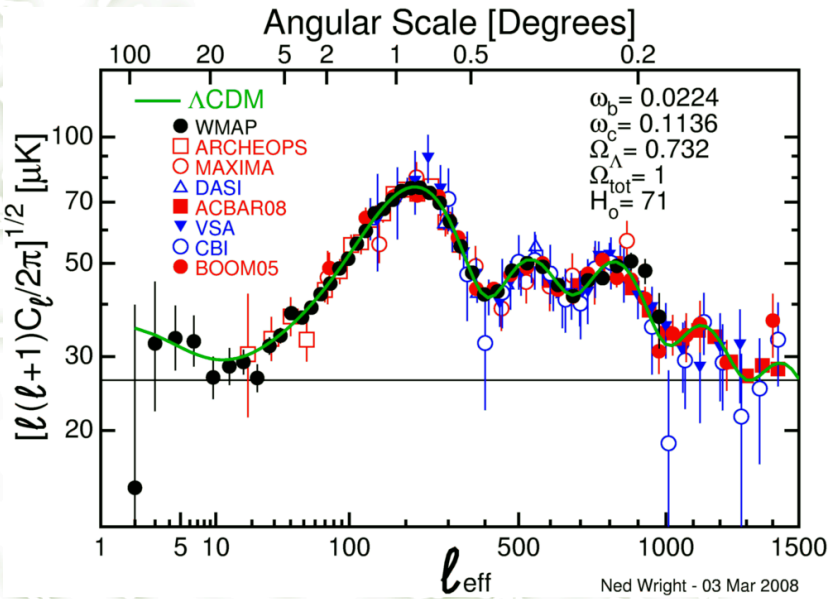
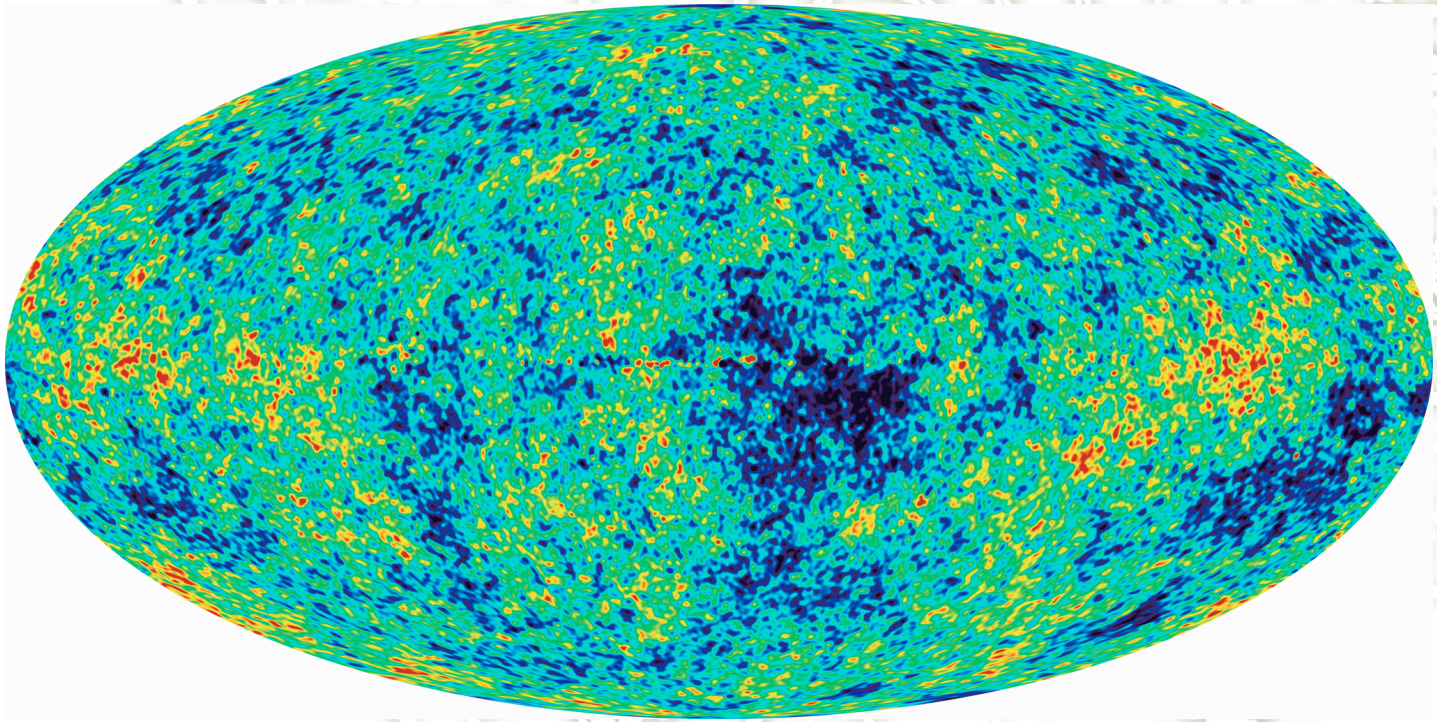
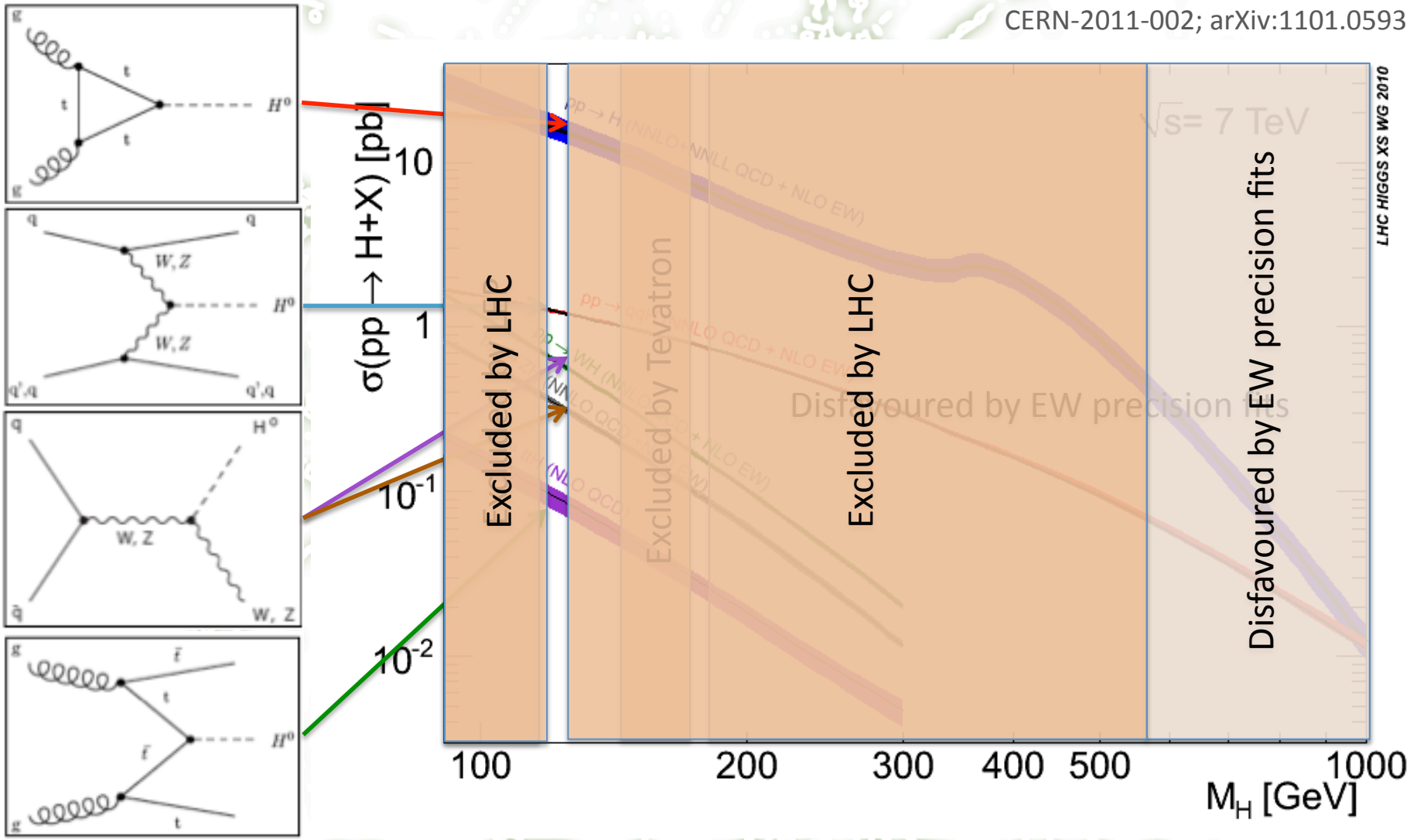
Bonus slides


Angular Scale [Degrees]
100
20
5
2
1
0.5
0.2
ΛCDM
WMAP
ARCHEOPS
MAXIMA
DASI
ACBAR08
VSA
CBI
BOOM05
ω_b= 0.0224
ω_c= 0.1136
Ω_Λ= 0.732
Ω_{tot}= 1
H_o= 71
$[\ell(\ell+1)C_\ell/2\pi]^{1/2}$ [μK]
100
70
50
30
20
1
5
10
100
500
1000
1500
ℓ_{eff}
Ned Wright - 03 Mar 2008



6 months ago: ICHEP 2012

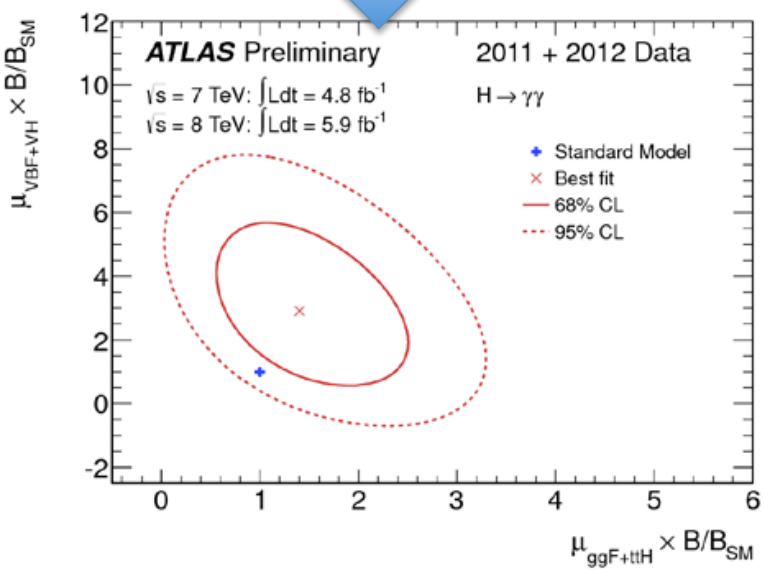
CERN-2011-002; arXiv:1101.0593

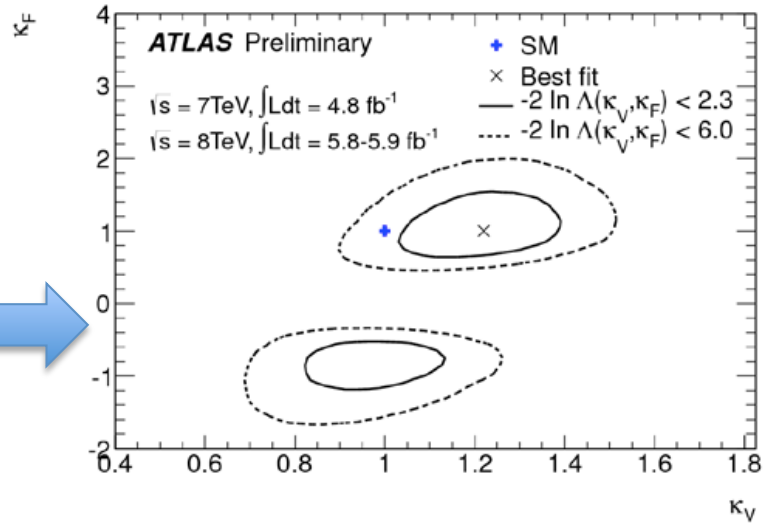


- What do we know about the new particle?
  - Mass ≈ 126 GeV
  - Electric charge = 0 (neutral final state)
- Unknown/incomplete knowledge:
  - Spin (*J*) = 0, 1, 2, ... ? *J*=1 disfavored (Landau-Yang theorem and observation in H→γγ)
  - Charge-conjugation, parity (CP)
  - Couplings?

- September analysis used same data as July 2012 observation paper
  - ATLAS-CONF-2012-127: https://cdsweb.cern.ch/record/1476765?ln=en
- Fit data to estimate factors *κ* multiplying coupling in each SM production and decay mode

Signal strength for the γγ final state (gluon fusion vs VBF+VH)



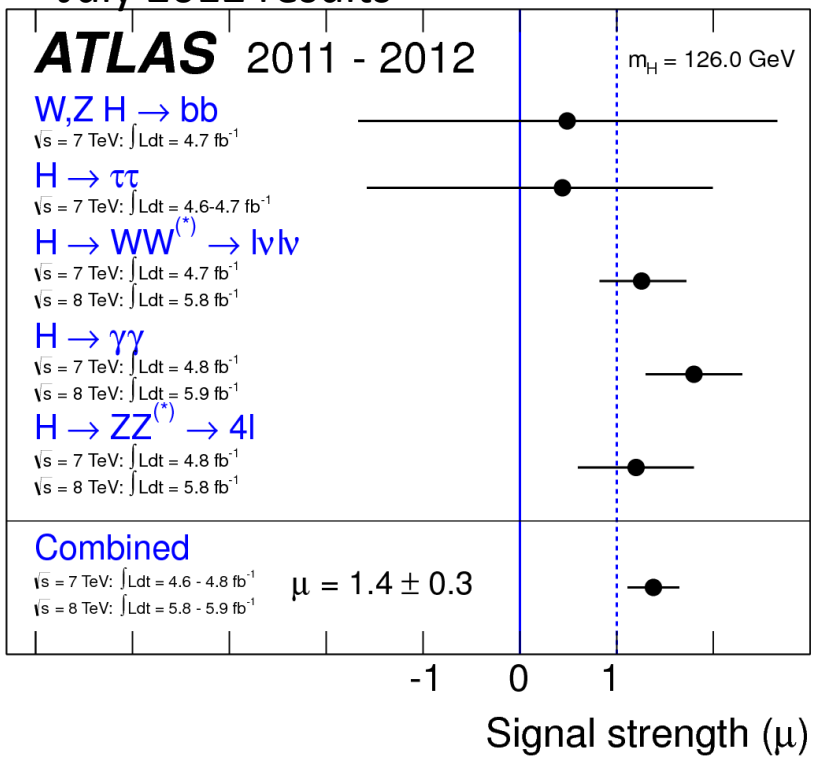


κ_V versus κ_F – assume a single κ_F factor for all fermions t, b, τ and a single factor κ_V for vector Sign comes from interference between t and W loops in H→γγ

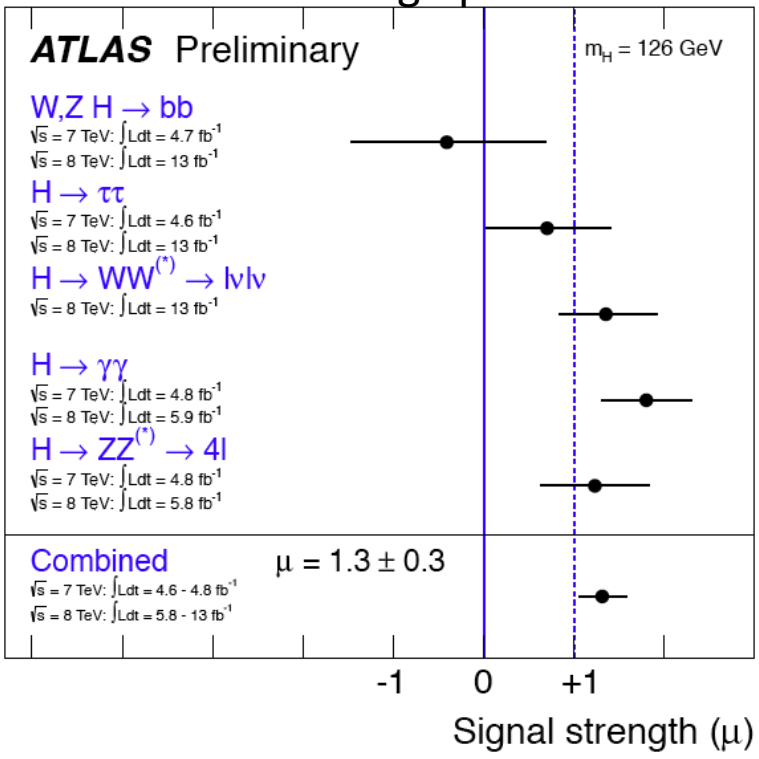
Updated signal strength

- Previous combined signal strength result: $\mu = 1.4 \pm 0.3$
  - 2011 analyses of $\tau\tau$ and bb, July analyses for $\gamma\gamma$, 4-lepton, and WW
- New result using analysis shown today: $\mu = 1.3 \pm 0.3$
  - Compatibility with SM μ=1 with observed measurement is 23%.

July 2012 results



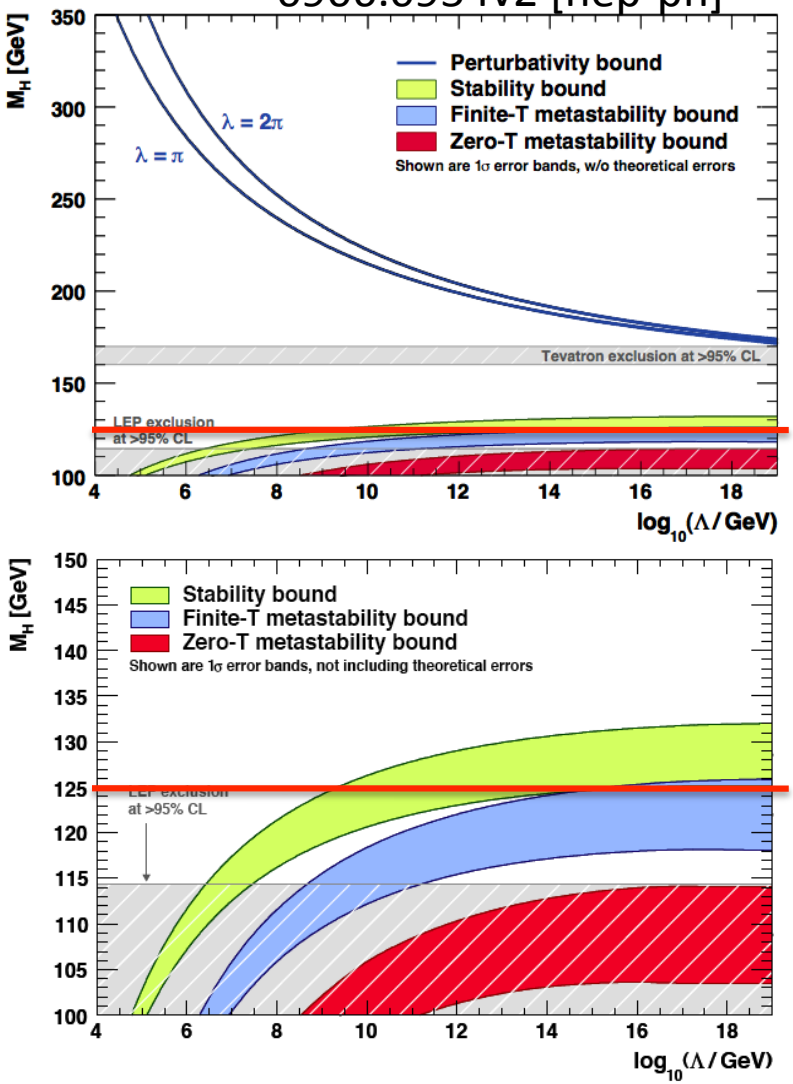
New result including updates shown



But there is more…

- We know the SM is incomplete
- For a low Higgs mass relative to the top quark mass, the quartic Higgs self-coupling runs at high energy towards lower values.
- At some point it would turn negative indicating that the vacuum is unstable.
- The universe could decay into a more stable lower energy vacuum state.
- Unless new physics appears at some energy scale
- The Higgs sector can give important clues to constrain new physics beyond the SM
- It is a great way to search for new physics!

0906.0954v2 [hep-ph]



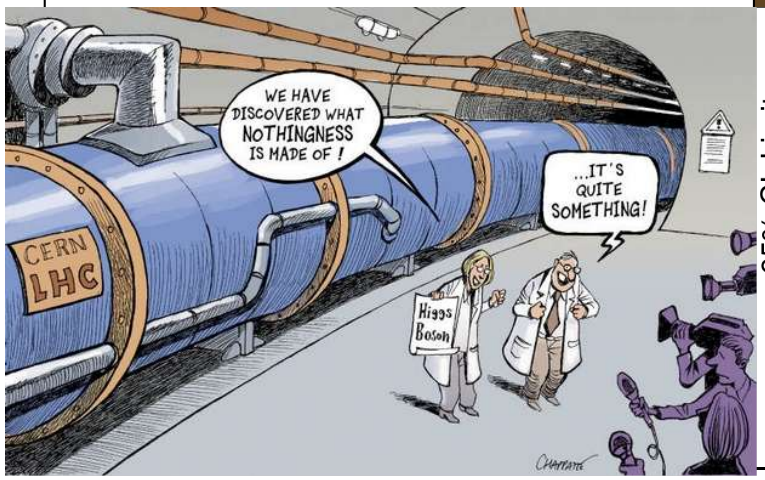
The story so far… we found a Higgs-like boson! ☺

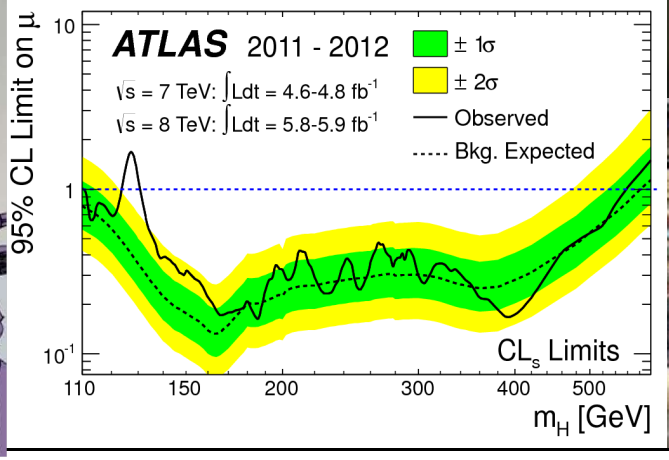
EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

CERN-PH-EP-2012-218

Accepted by: Physics Letters B

Observation of a New Particle in the Search for the Standard Model Higgs Boson with the ATLAS Detector at the LHC






CERN