Um Universo de Partículas

O infinitamente pequeno e o infinitamente grande…

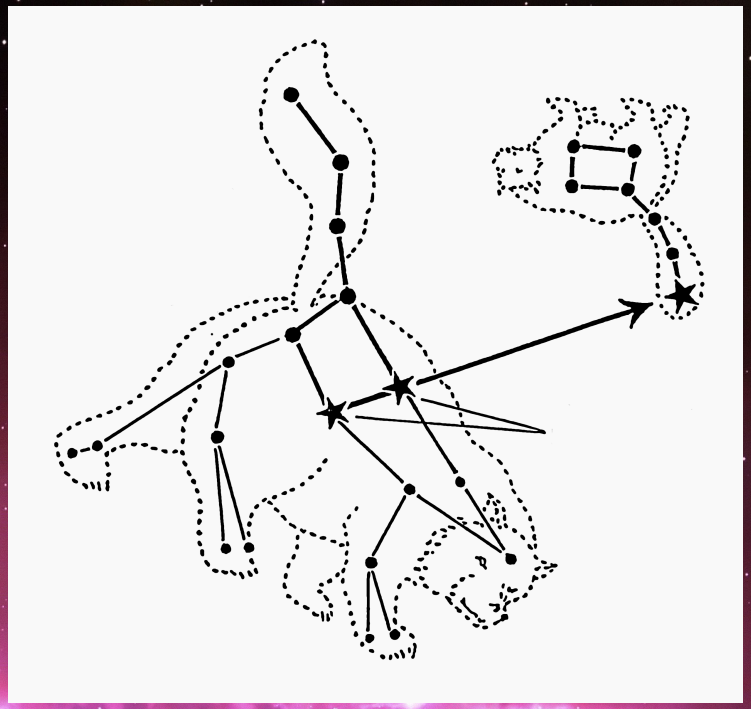
Ricardo Gonçalo, Laboratório de Instrumentação e Física Experimental de Partículas (LIP)

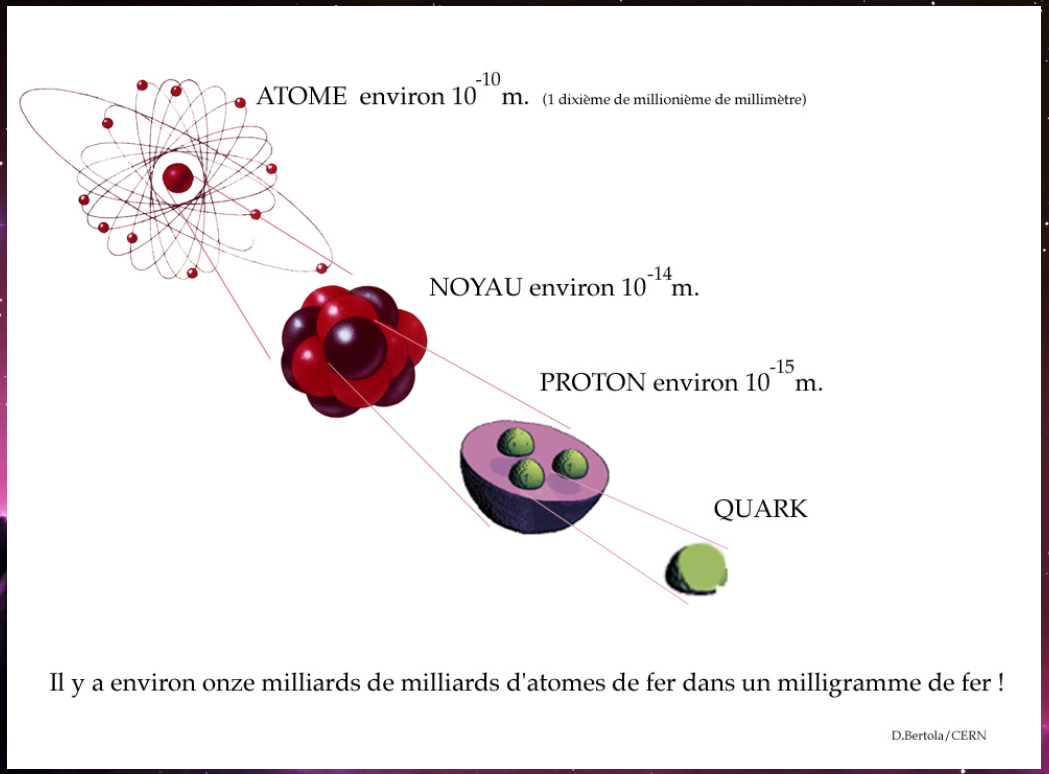
Noite dos Investigadores – Planetário Gulbenkian – Lisboa, 26 de Setembro 2014

LIP
60 ANOS CERN
IF INVESTIGADOR FCT
QUALIFICAR É CRESCER.
UNIÃO EUROPEIA Fundo Social Europeu
QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL PORTUGAL 2007.2013
Escolher Ciência
Ciência Viva

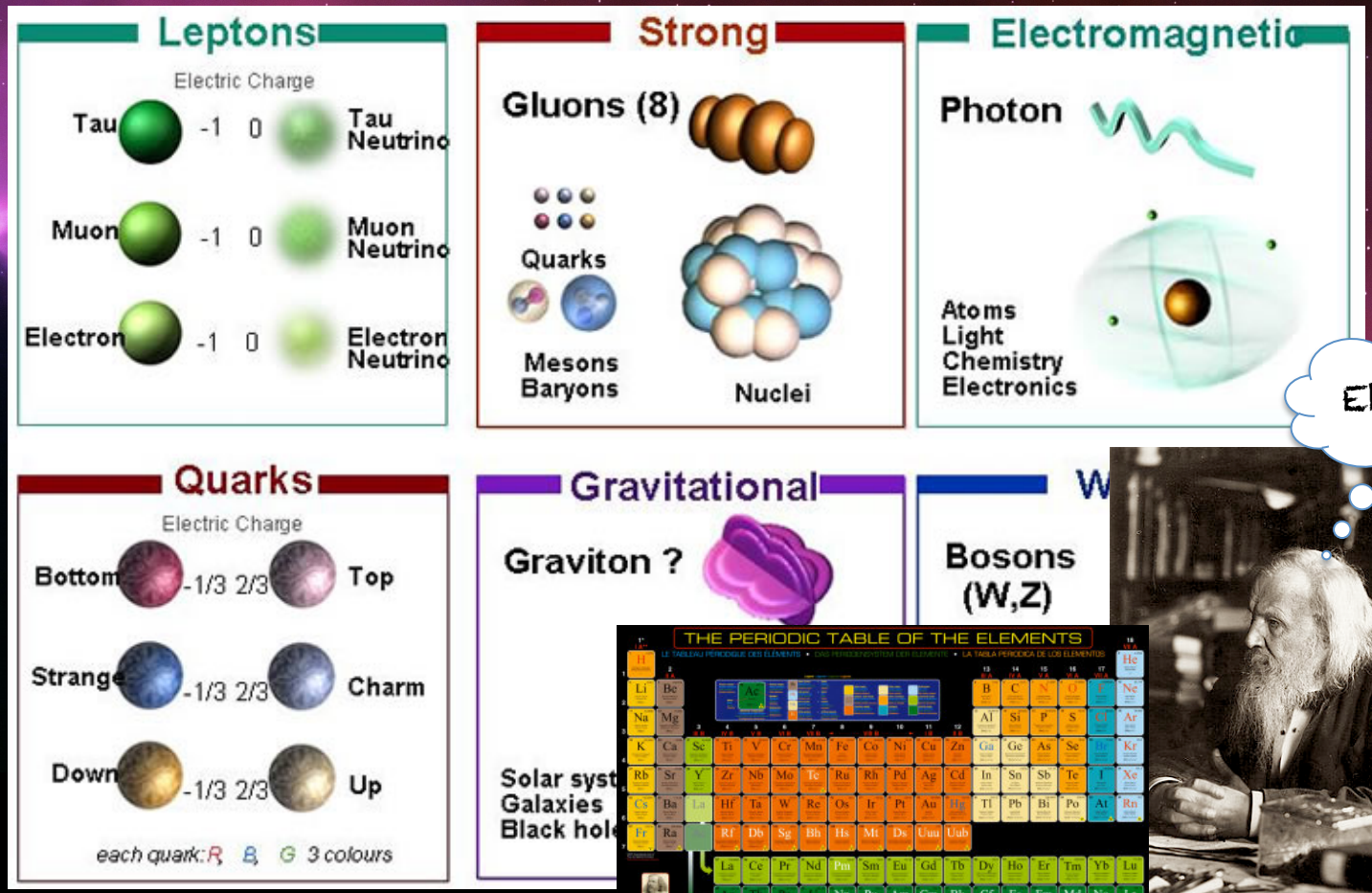
Sumário

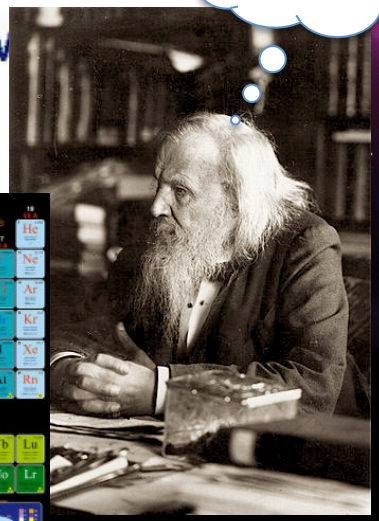
- O que sabemos
- O que acabámos de descobrir
- O que realmente NÃO sabemos



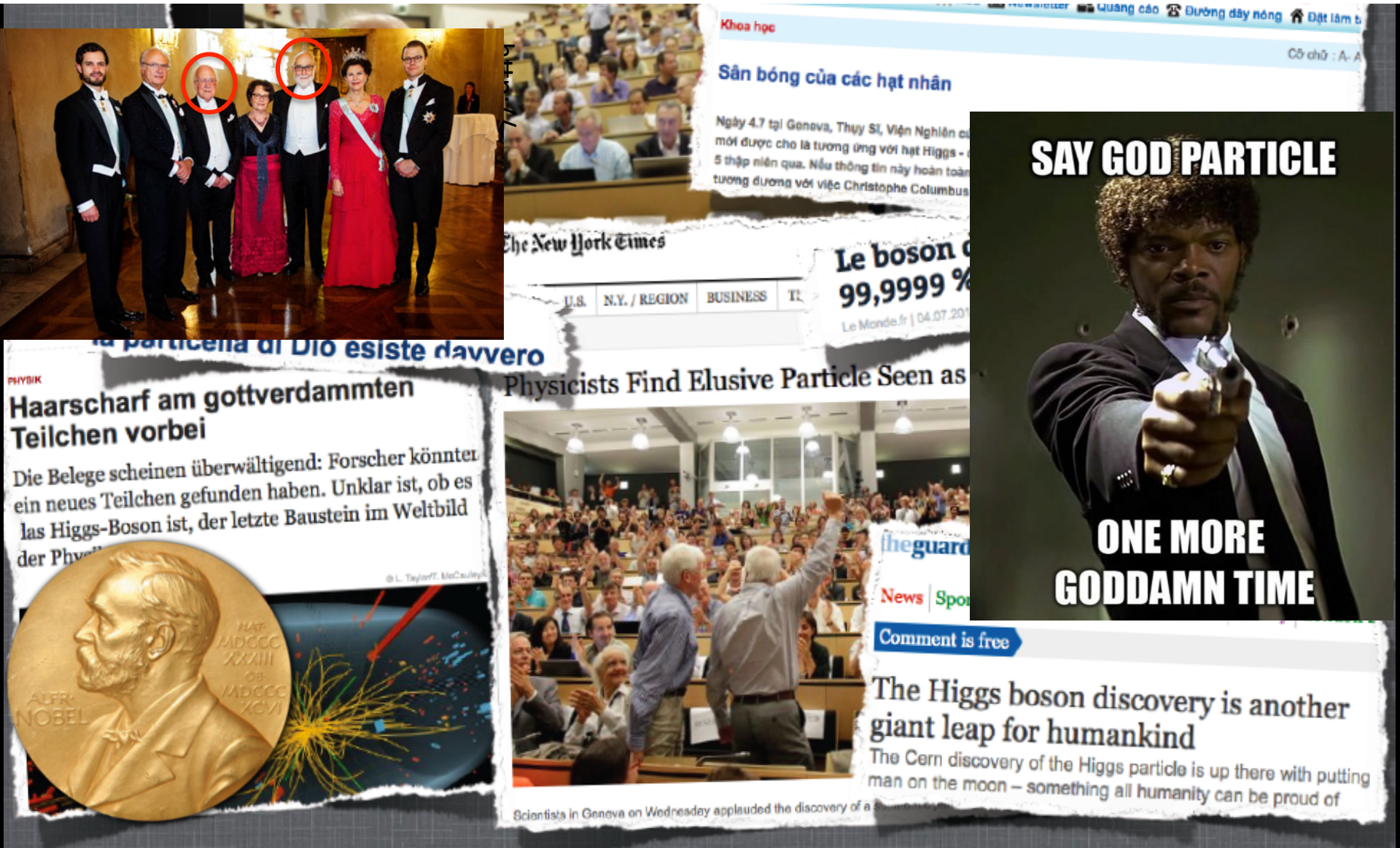

ATOME environ 10^{-10} m. (1 dixième de millionième de millimètre)
NOYAU environ 10^{-14} m.
PROTON environ 10^{-15} m.
QUARK
Il y a environ onze milliards de milliards d'atomes de fer dans un milligramme de fer !
D.Bertola/CERN

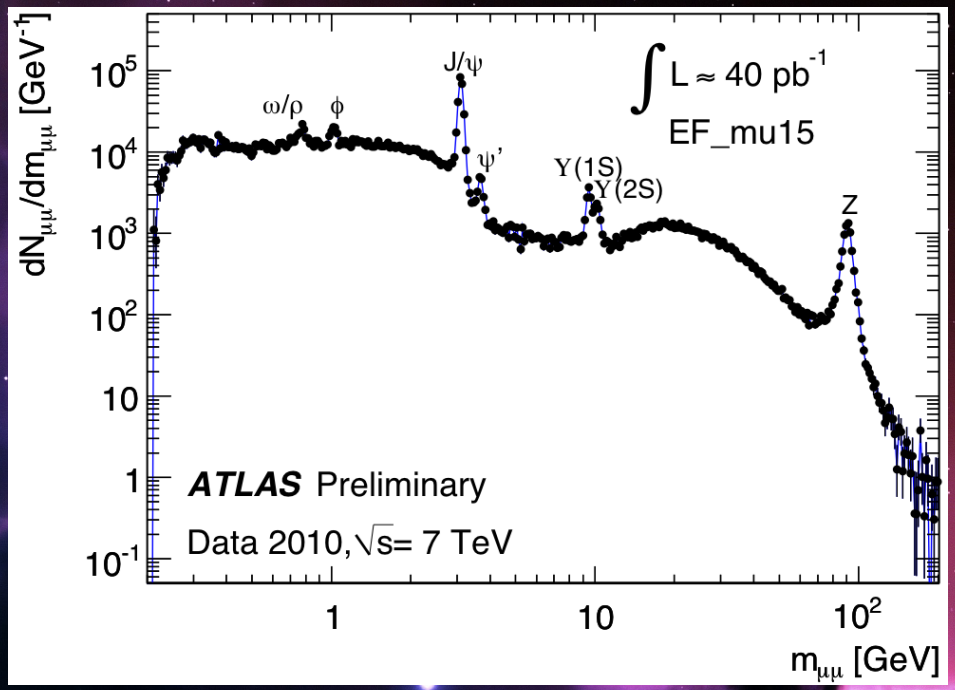
O Modelo Padrão

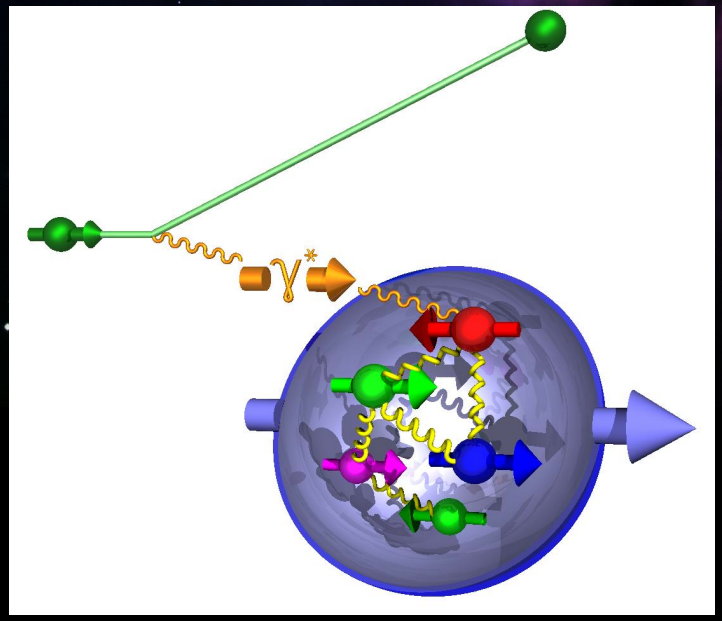


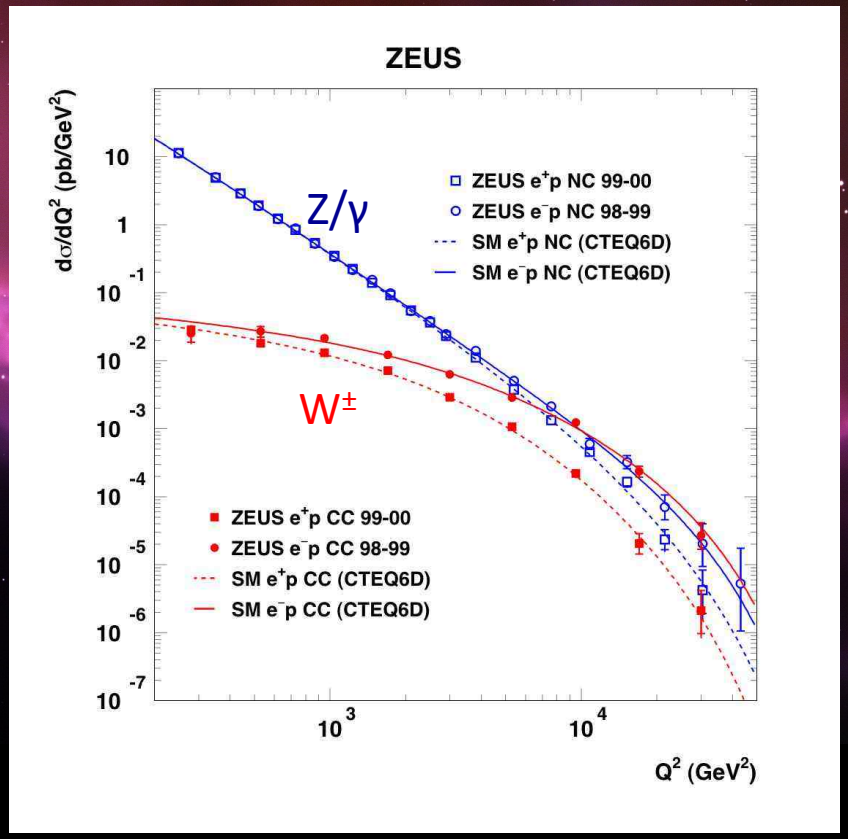


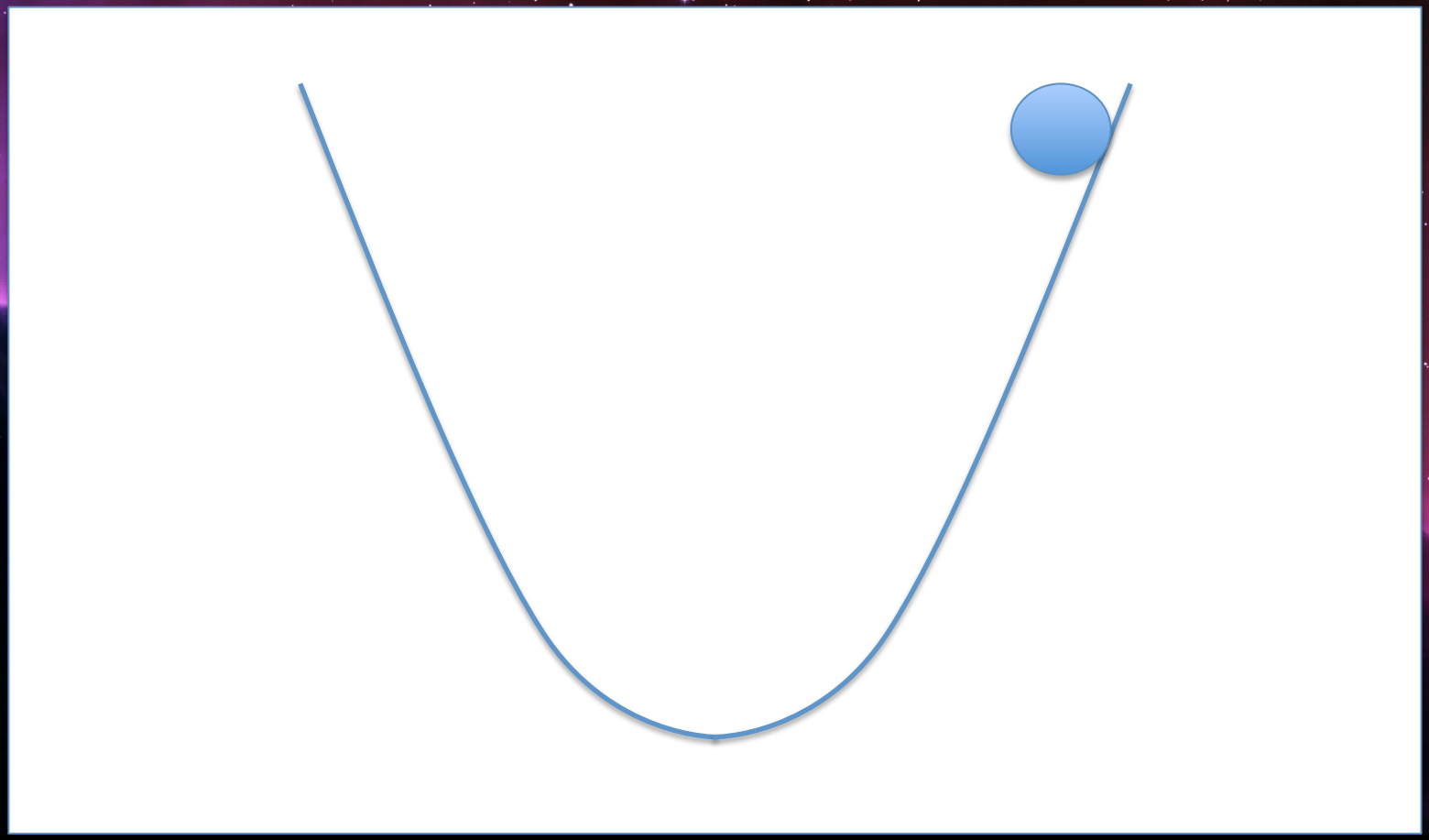
O que é o bosão acabamos de descobrir?




$dN_{\mu\mu}/dm_{\mu\mu}$ [GeV^{-1}]
$\int L \approx 40$ pb^{-1}
EF_mu15
ω/ρ
φ
J/ψ
ψ'
Υ(1S)
Υ(2S)
Z
ATLAS Preliminary
Data 2010, $\sqrt{s}$= 7 TeV
$m_{\mu\mu}$ [GeV]

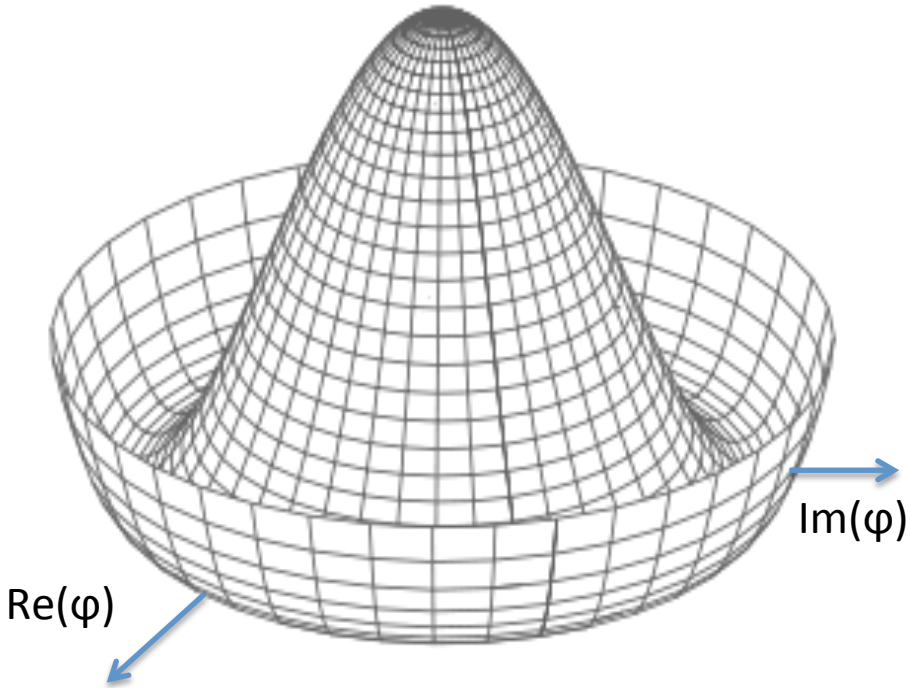

γ*


ZEUS
$d\sigma/dQ^2$ (pb/GeV^2)
Z/γ
W±
ZEUS e+p NC 99-00
ZEUS e−p NC 98-99
SM e+p NC (CTEQ6D)
SM e−p NC (CTEQ6D)
ZEUS e+p CC 99-00
ZEUS e−p CC 98-99
SM e+p CC (CTEQ6D)
SM e−p CC (CTEQ6D)
Q^2 (GeV^2)

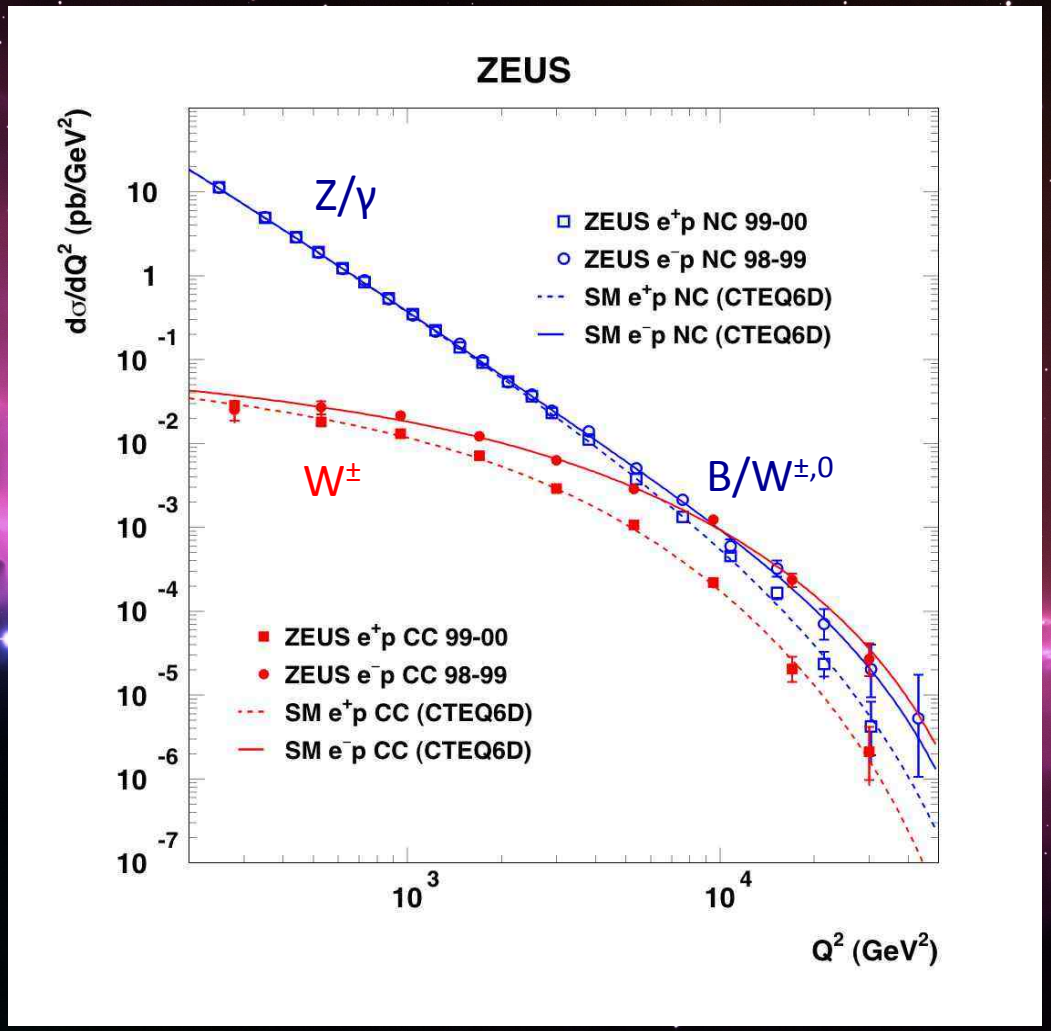


10^{-11} segundos depois do Big Bang...

$$\phi = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix}$$



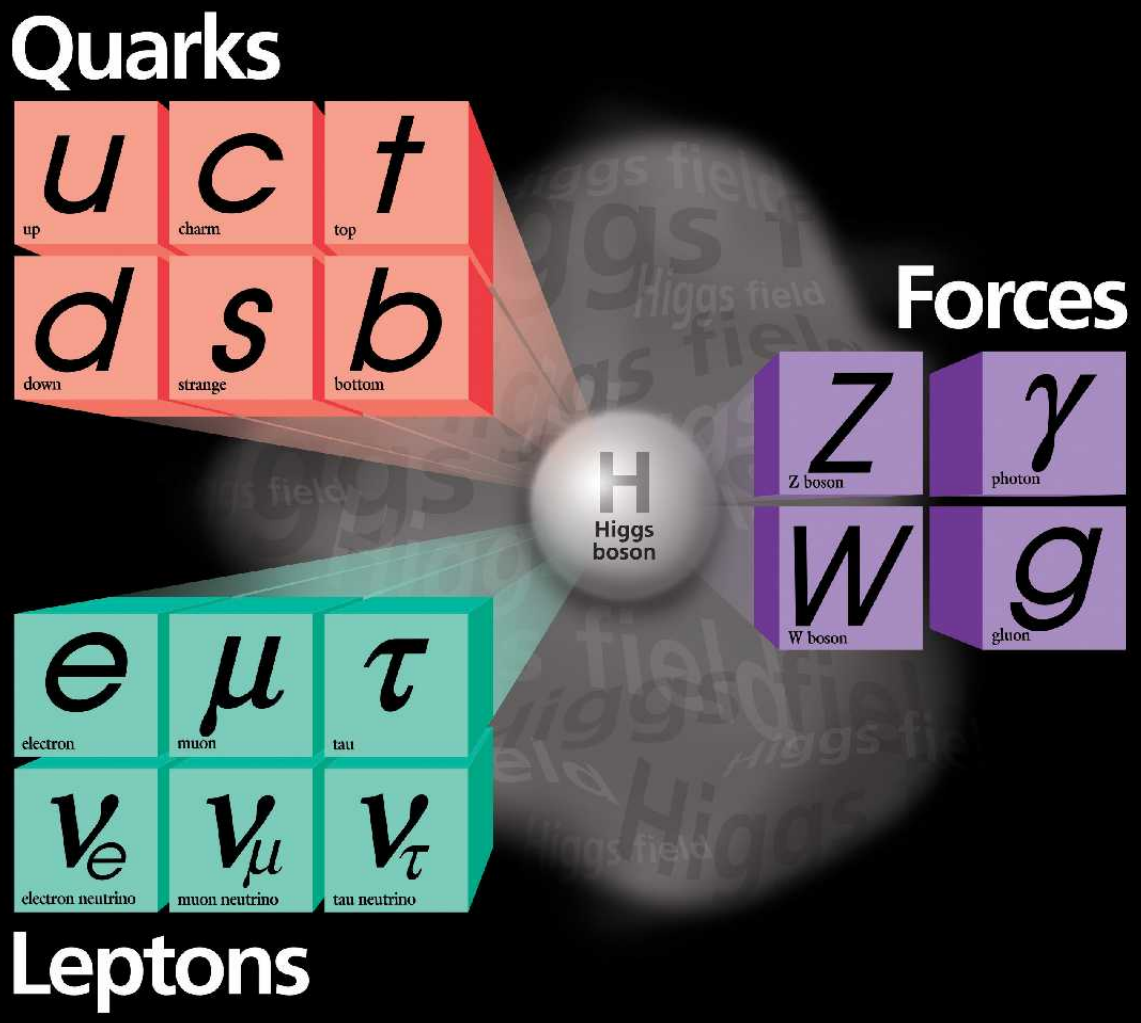
γ
Z^0
W^+
W^-
+

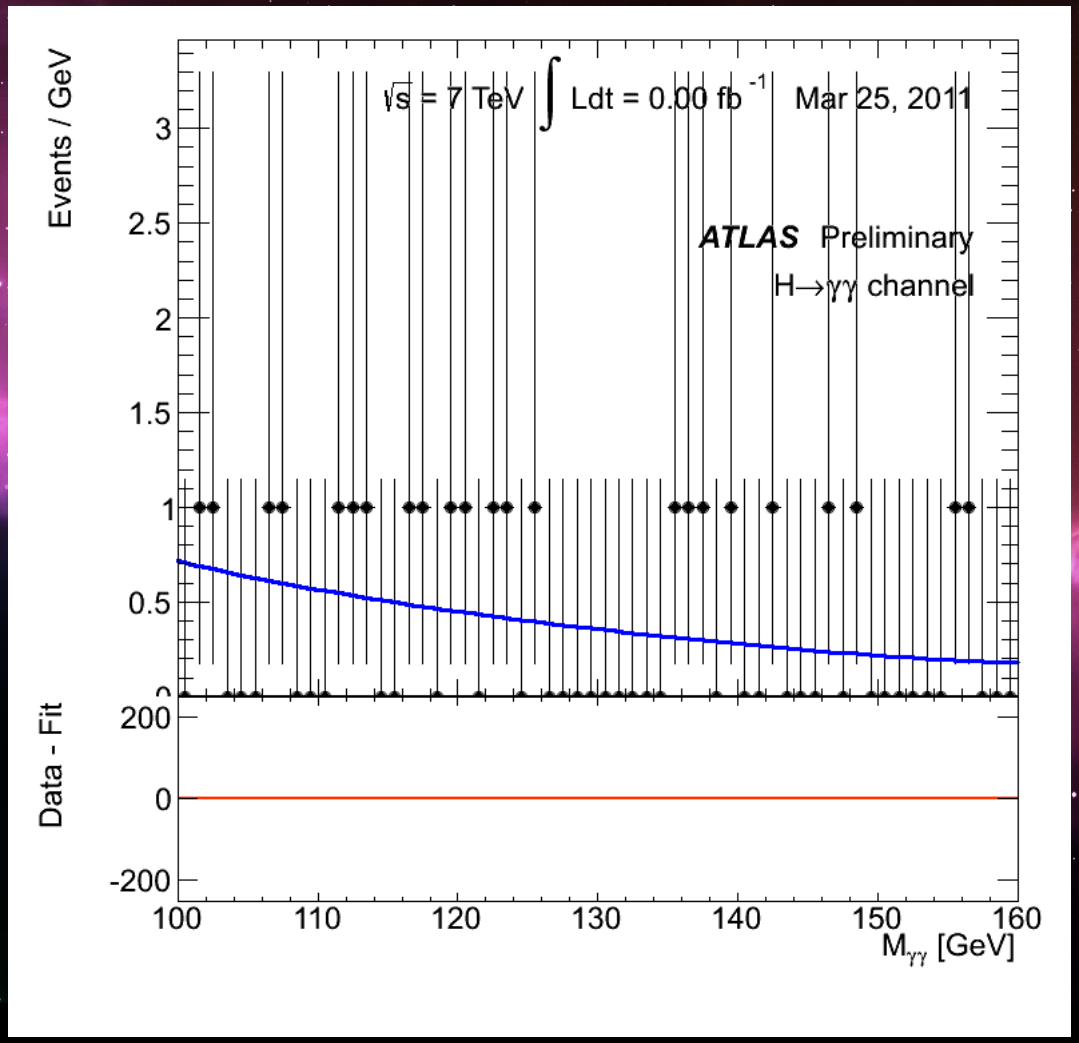


B
W^+
W^-
W^0

Hoje

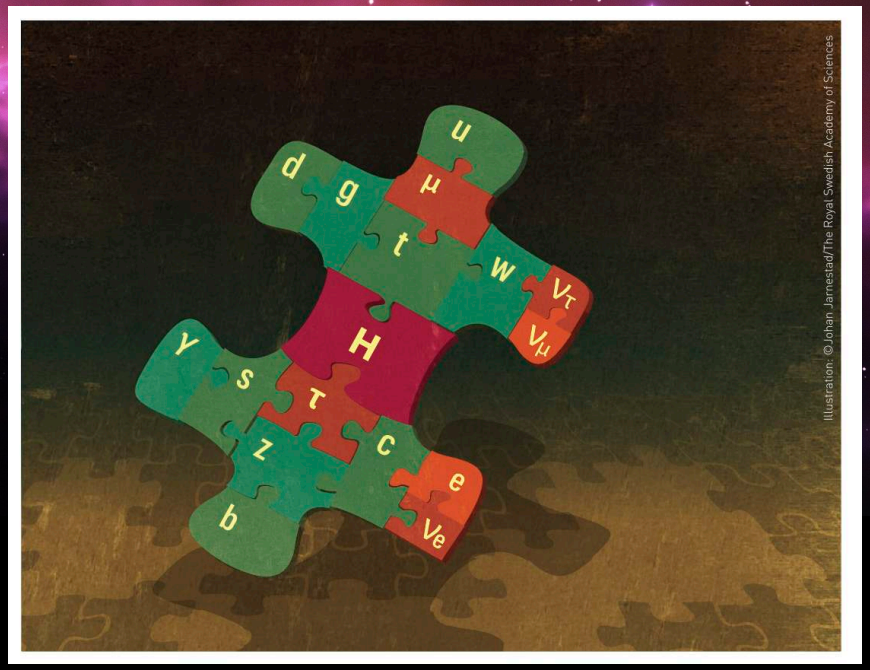
Big Bang

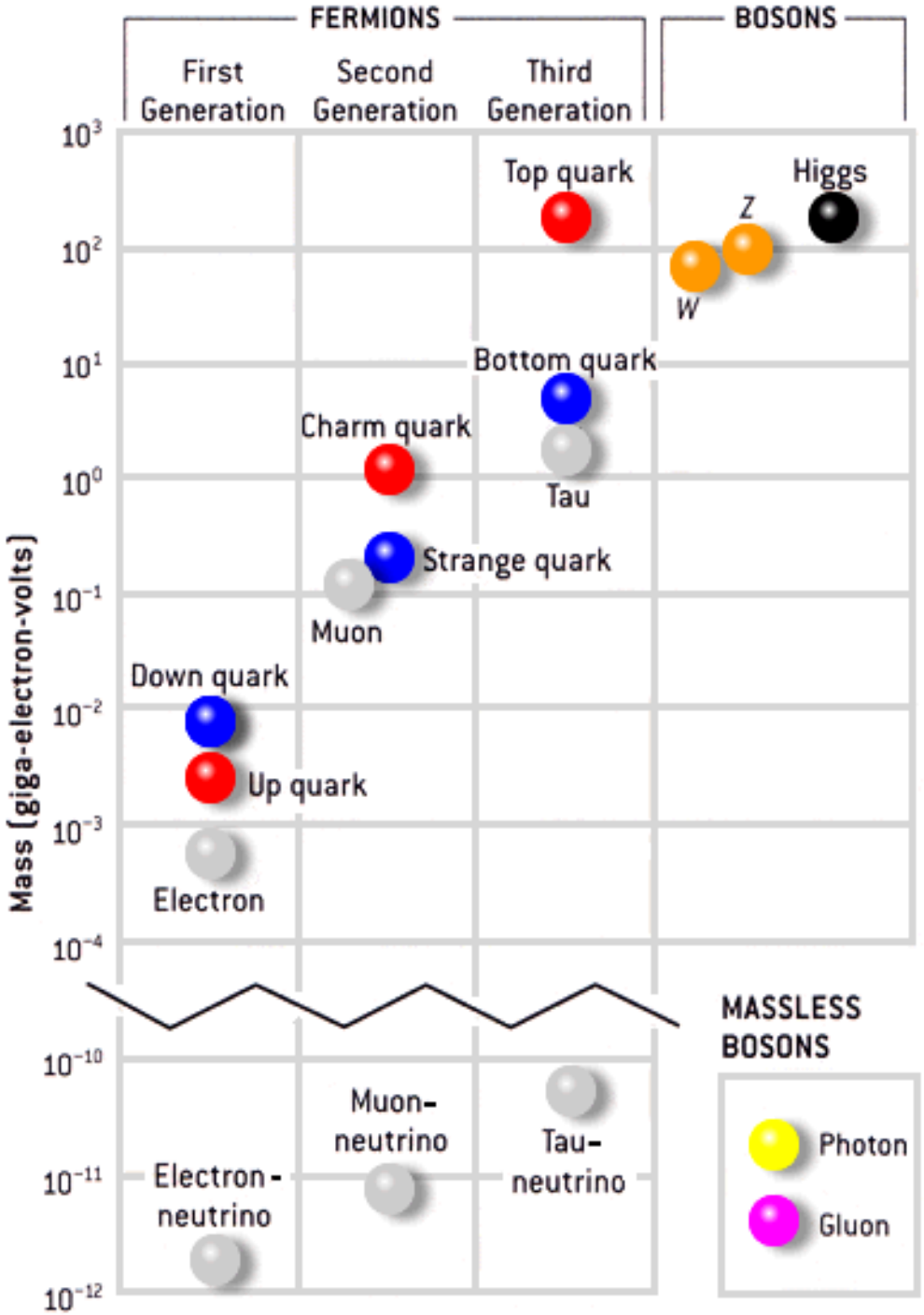

Quarks
u
up
c
charm
t
top
d
down
s
strange
b
bottom
Forces
Z
Z boson
γ
photon
W
W boson
g
gluon
H
Higgs boson
e
electron
μ
muon
τ
tau
νe
electron neutrino
νμ
muon neutrino
ντ
tau neutrino
Leptons

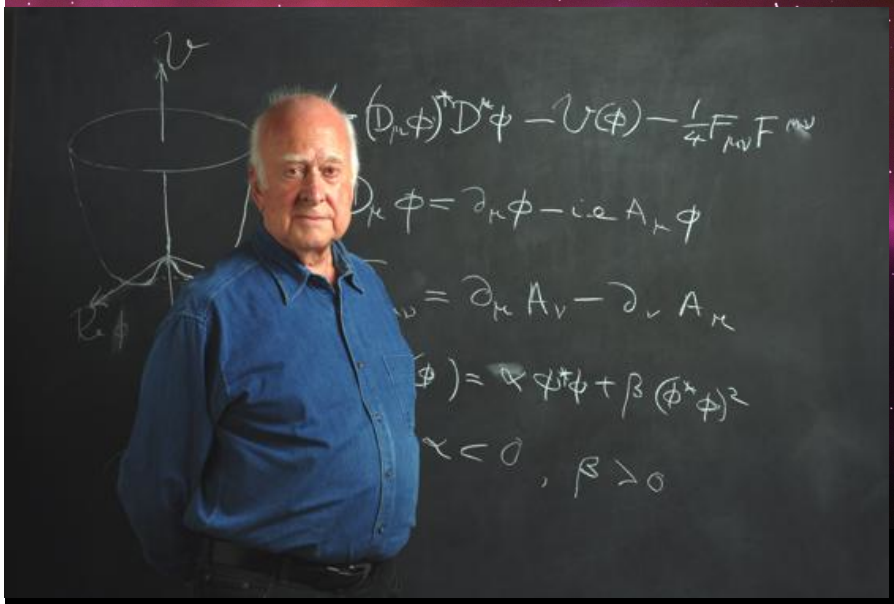

√s = 7 TeV ∫ Ldt = 0.00 fb⁻¹ Mar 25, 2011
ATLAS Preliminary
H→γγ channel
Events / GeV
Data - Fit
M_γγ [GeV]

E agora?...

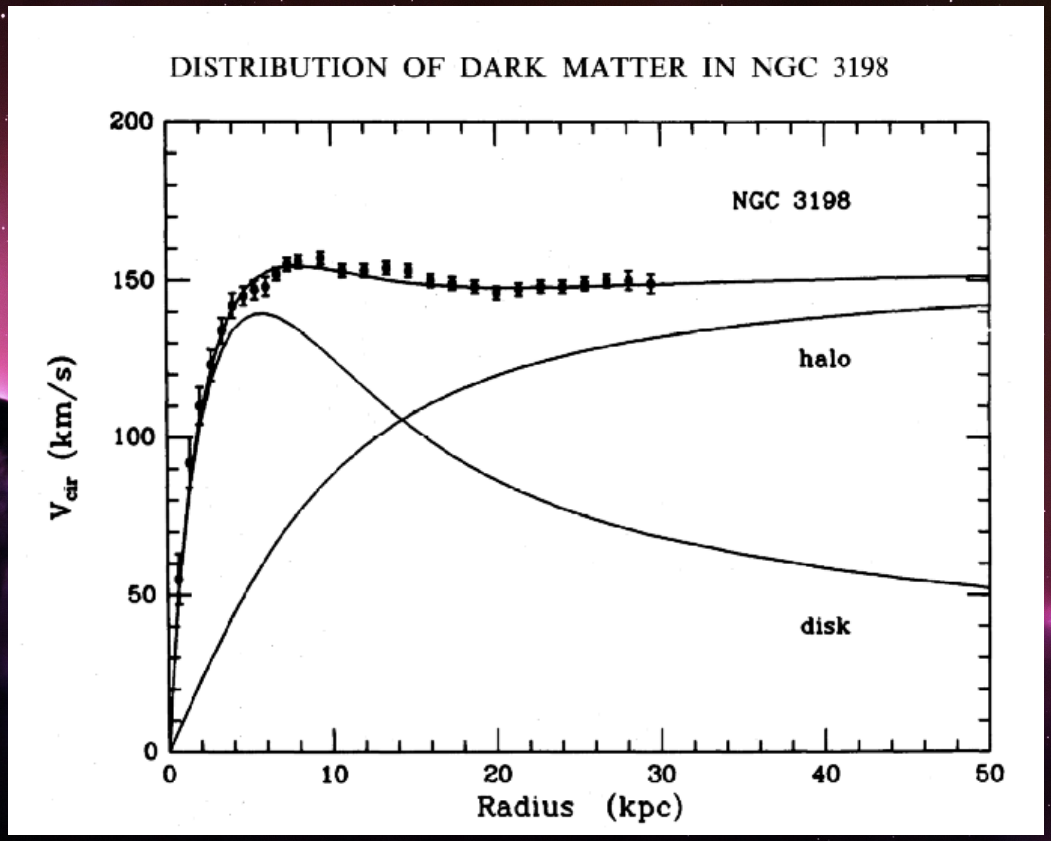
- O Modelo Standard NÃO pode ser o puzzle completo!
- Há uma dinâmica subjacente ao mecanismo de Higgs?
- Porque é que a força das interacções e as massas das partículas são tão diferentes?
- E porque é que a expansão do universo é acelerada? Energia escura!
- União das forças a alta energia?
- Para onde foi a antimatéria?
- O que é a matéria escura?




FERMIONS
BOSONS
First Generation
Second Generation
Third Generation
Mass (giga-electron-volts)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-10}
10^{-11}
10^{-12}
Top quark
Higgs
Z
W
Bottom quark
Charm quark
Tau
Strange quark
Muon
Down quark
Up quark
Electron
Muon-neutrino
Tau-neutrino
Electron-neutrino
MASSLESS BOSONS
Photon
Gluon



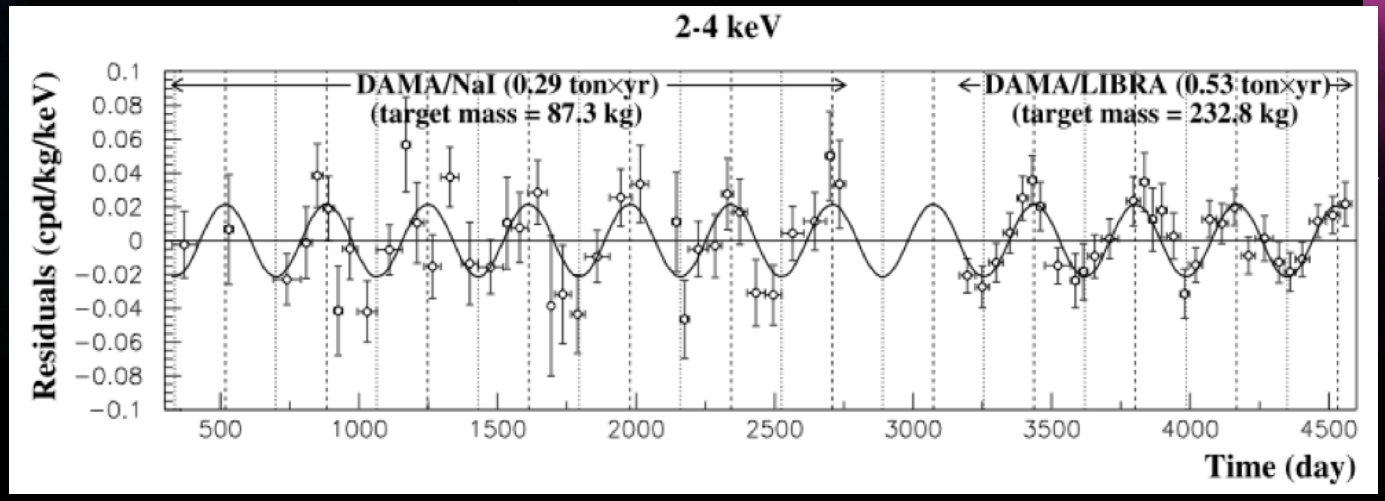
Matéria Escura



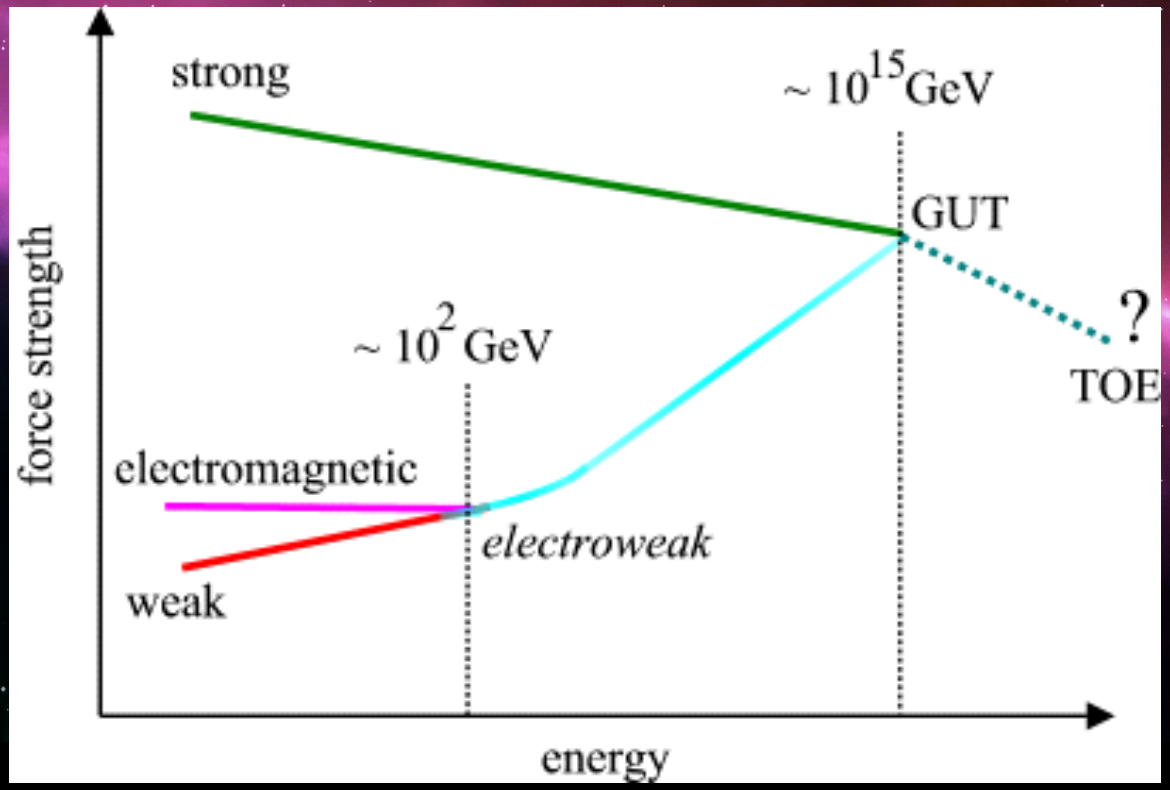
- Sabemos que existe:
  - Rotação de galáxias
  - Radiação de fundo
  - Microlensing
- Mas **não sabemos o que é**!

Galaxy Cluster Abell 2218 **HST • WFPC2**

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



Unificação das interacções?




Há muito mais por descobrir!

Perguntas?


QUI A PEUR
DU
TROU NOIR


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!
MOREU

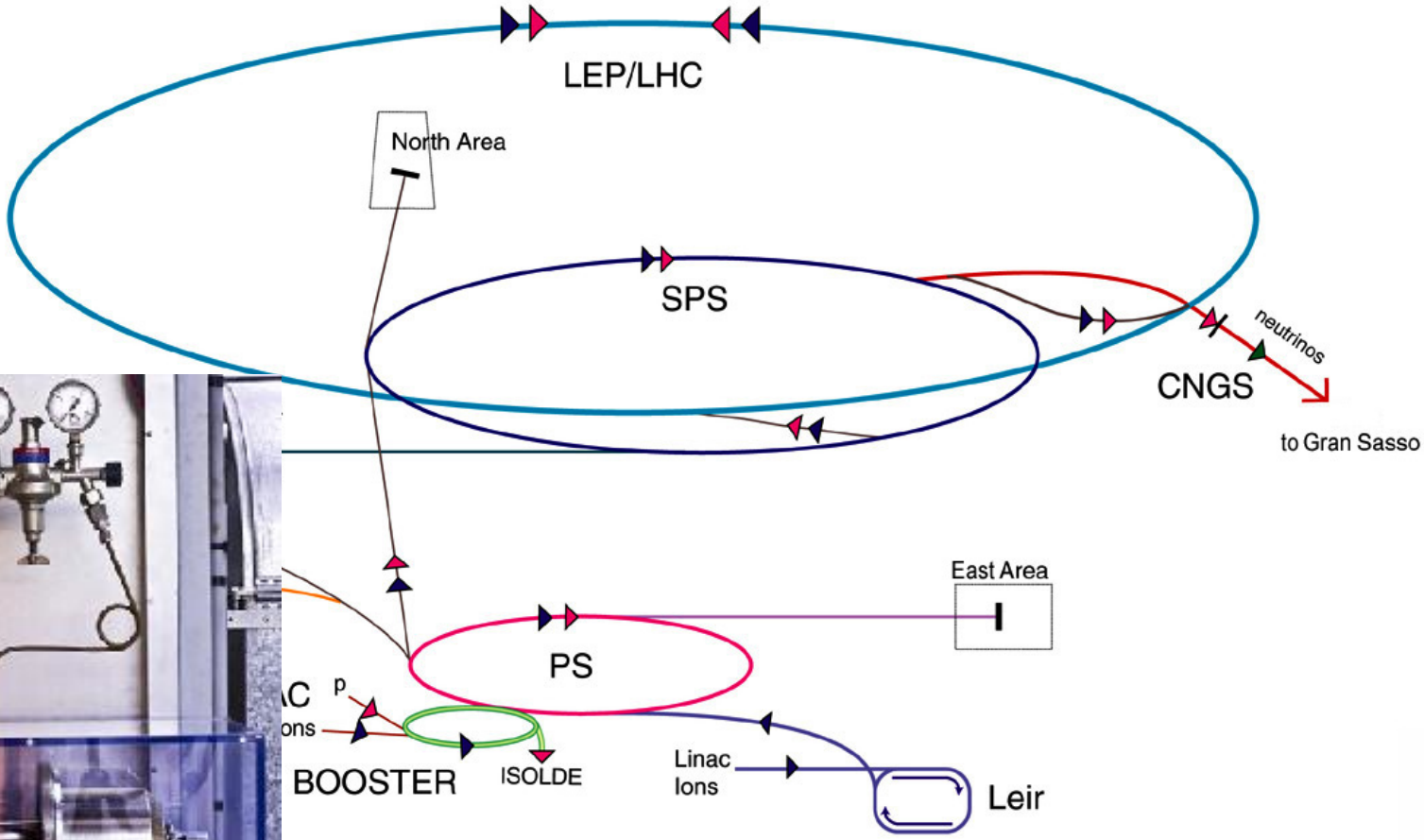
LINAC2 → **50 MeV**

Booster → **1.4 GeV**

Proton Synchroton (PS) → **25 GeV**

Super Proton Synchrotron (SPS) → **450 GeV**

Large Hadron Collider (LHC)→ **7 TeV**

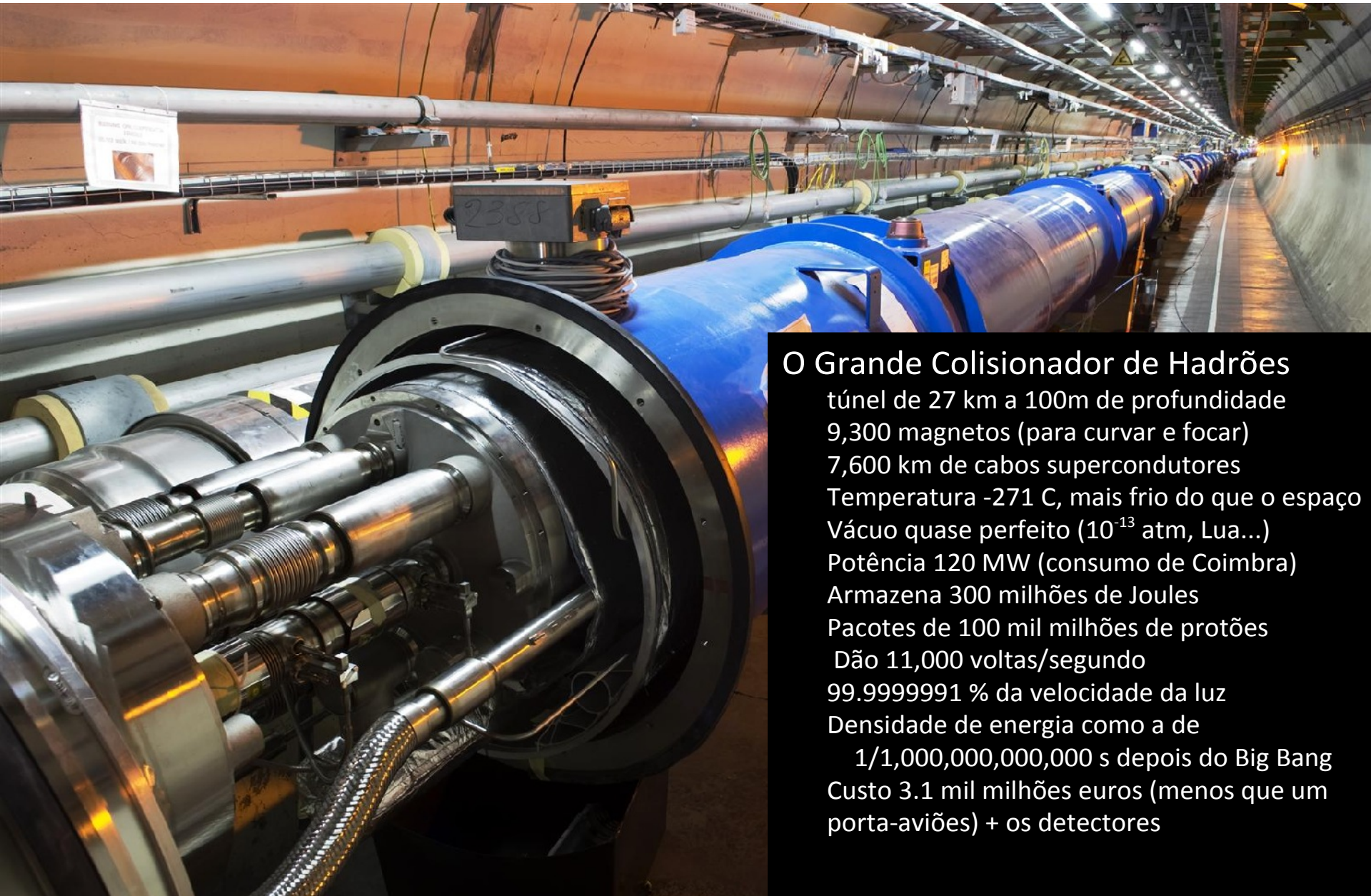


roton conversion

AD Antiproton Decelerator
PS Proton Synchrotron
SPS Super Proton Synchrotron

LHC Large Hadron Collider
n-ToF Neutron Time of Flight
CNGS Cern Neutrinos Gran Sasso

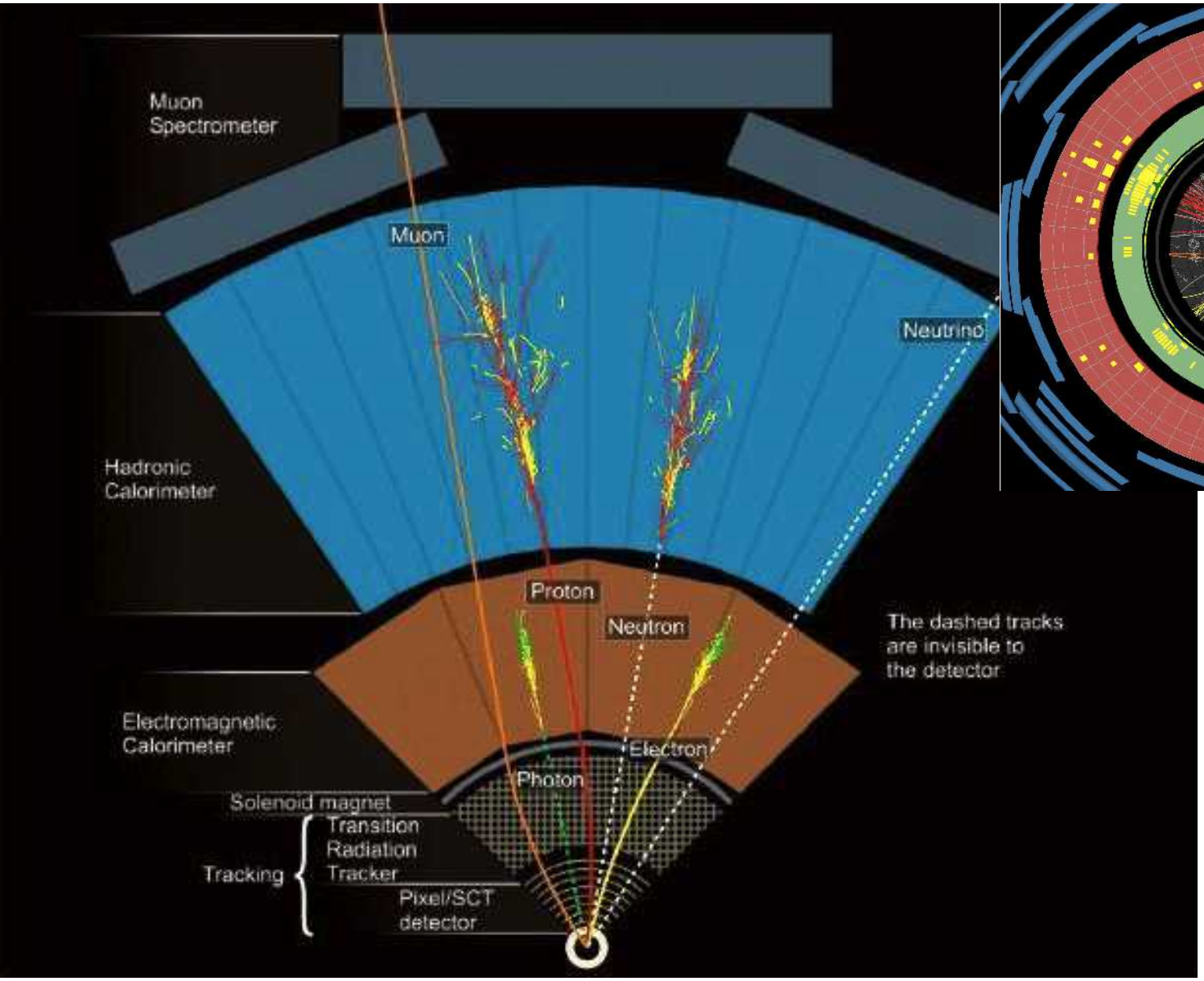
Large Hadron Collider

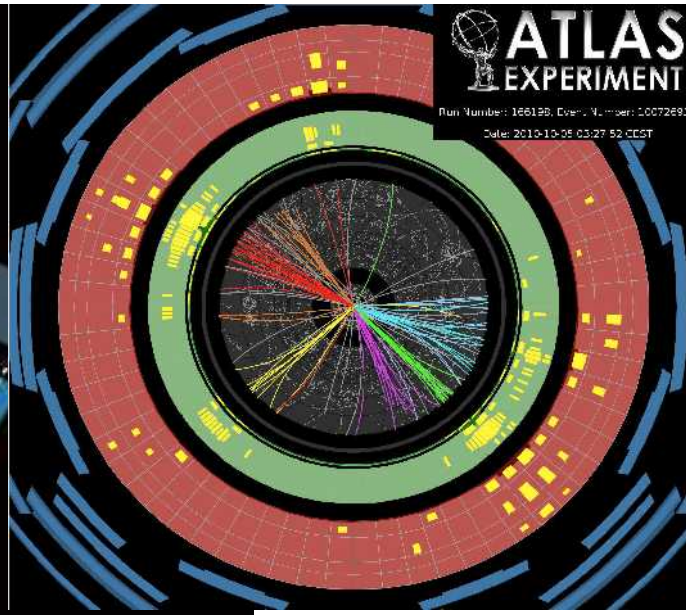


O Grande Colisionador de Hadrões

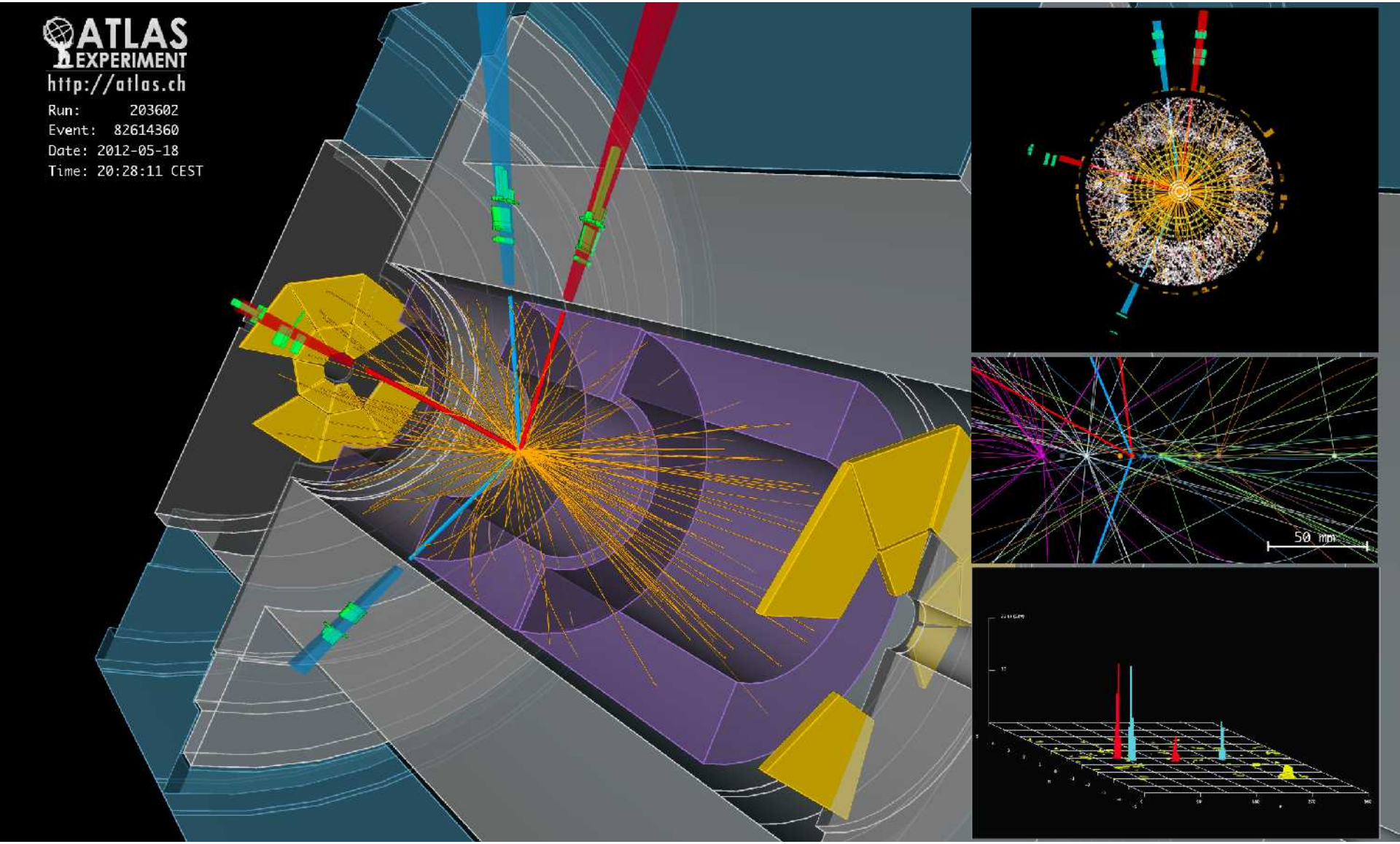
túnel de 27 km a 100m de profundidade
9,300 magnetos (para curvar e focar)
7,600 km de cabos supercondutores
Temperatura -271 C, mais frio do que o espaço
Vácuo quase perfeito (10^{-13} atm, Lua...)
Potência 120 MW (consumo de Coimbra)
Armazena 300 milhões de Joules
Pacotes de 100 mil milhões de protões
Dão 11,000 voltas/segundo
99.9999991 % da velocidade da luz
Densidade de energia como a de
1/1,000,000,000,000 s depois do Big Bang
Custo 3.1 mil milhões euros (menos que um porta-aviões) + os detectores

Como se detectam partículas

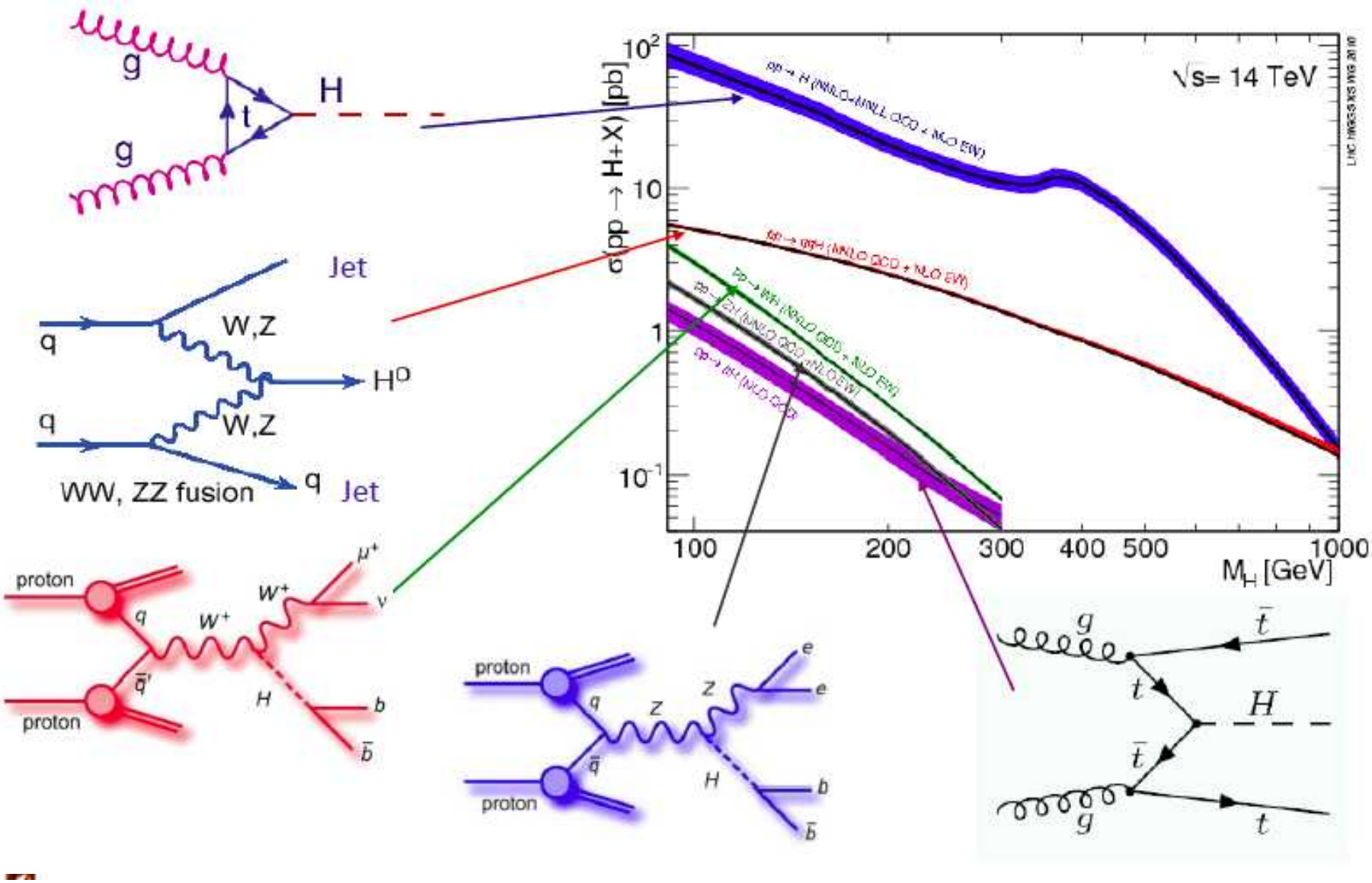




Higgs → 2Z → 4e


ATLAS
EXPERIMENT
http://atlas.ch
Run: 203602
Event: 82614360
Date: 2012-05-18
Time: 20:28:11 CEST
50 mm

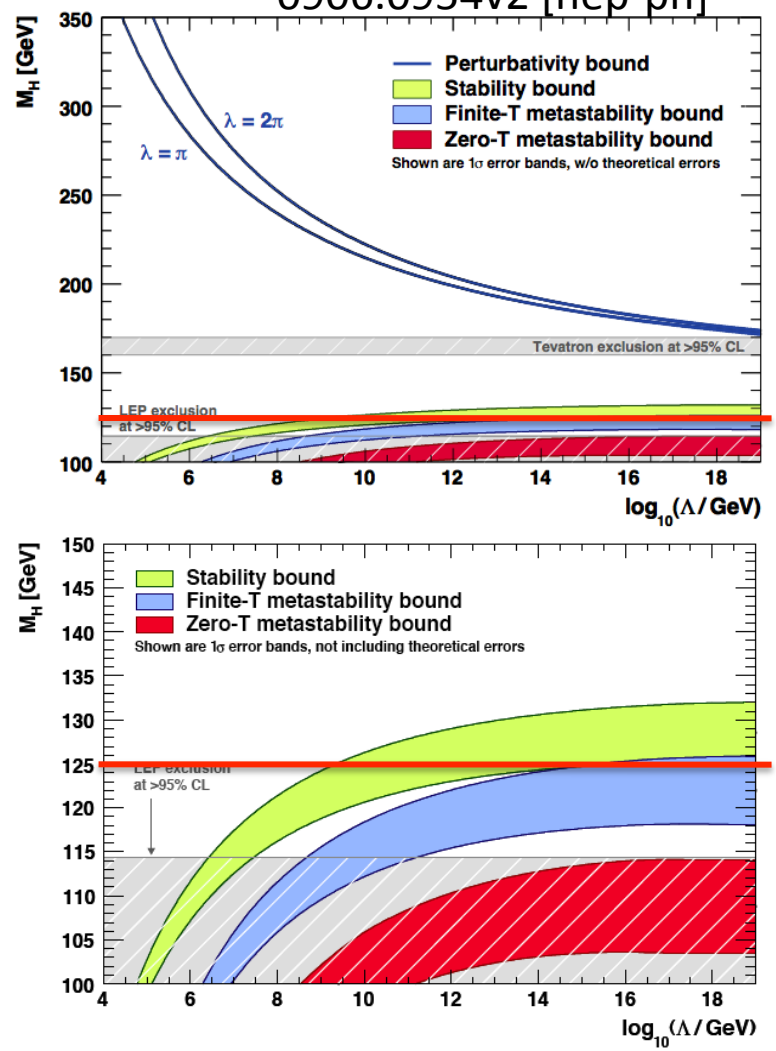
Modos de produção do bosão de Higgs



But there is more…

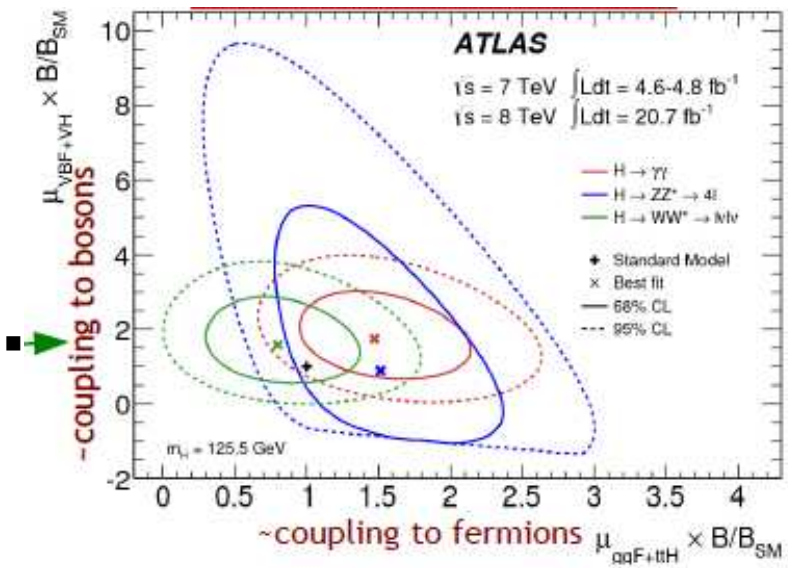
- We know the SM is incomplete
- For a low Higgs mass relative to the top quark mass, the quartic Higgs self-coupling runs at high energy towards lower values.
- At some point it would turn negative indicating that the vacuum is unstable.
- The universe could decay into a more stable lower energy vacuum 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!

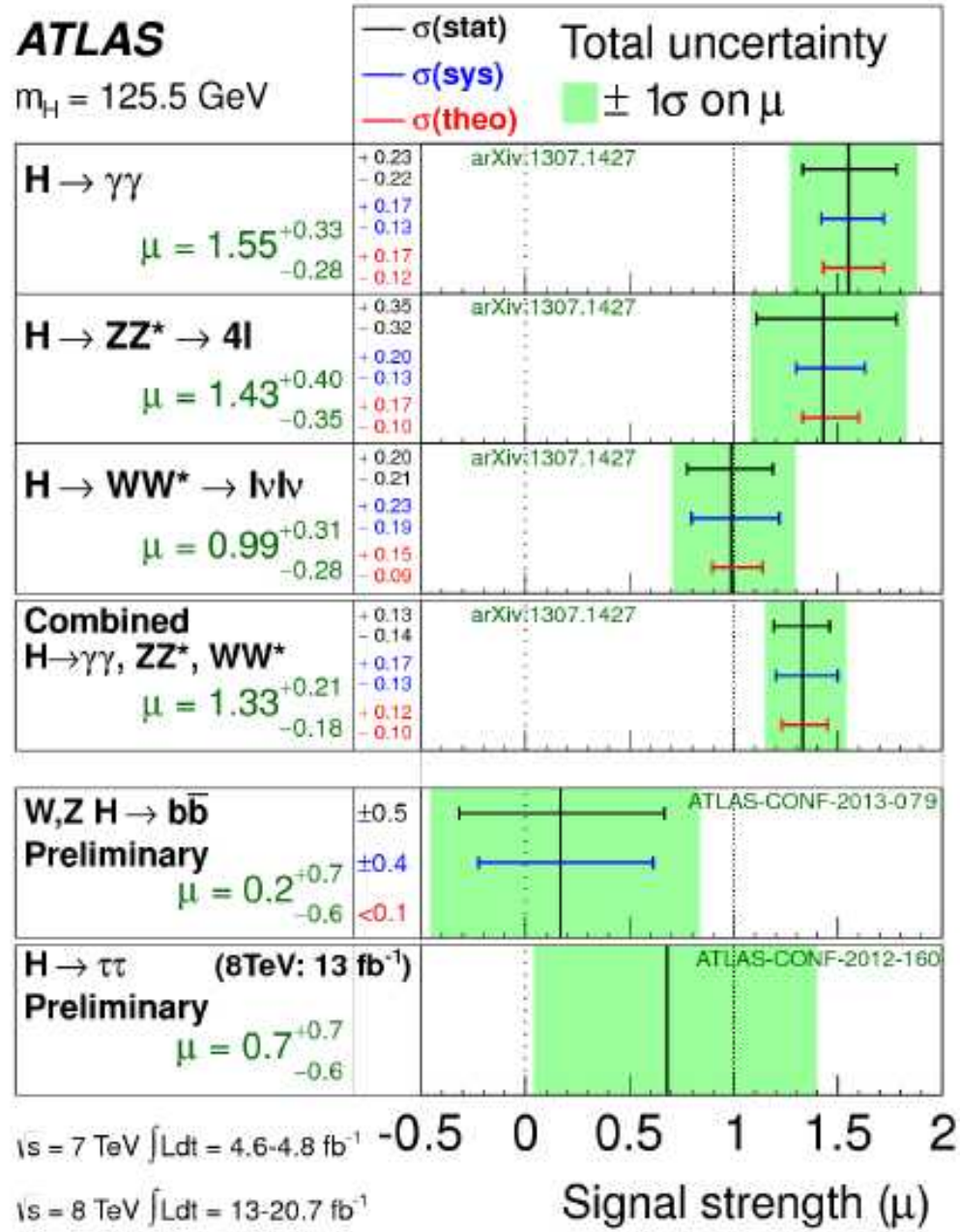
0906.0954v2 [hep-ph]



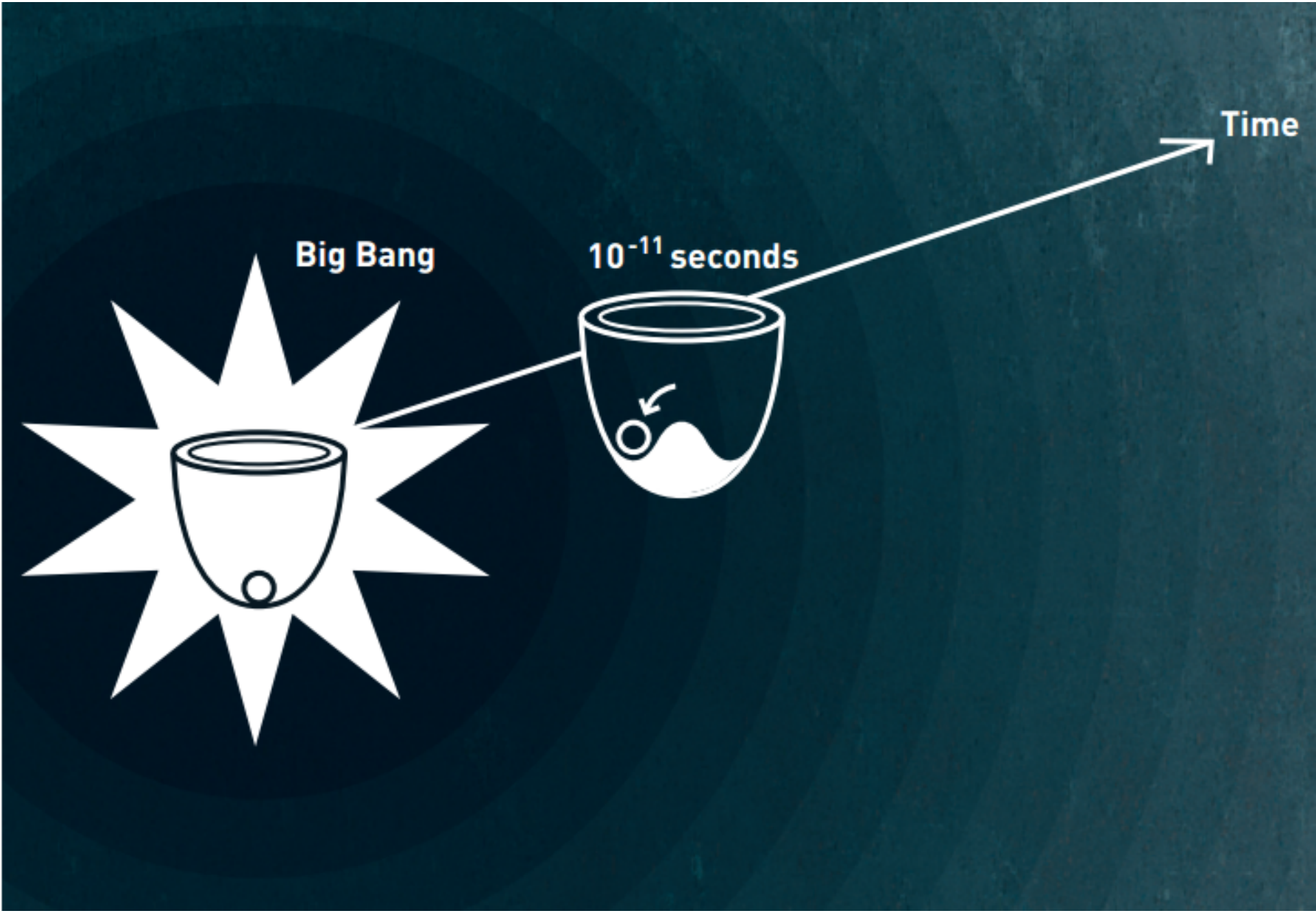
É o Higgs !

- Quais as propriedades ?
  - spin 0+
  - massa 125.5 GeV
  - acoplamentos previstos pelo Modelo I





- Razão μ =dados / teoria


Time
Big Bang
10^{-11} seconds