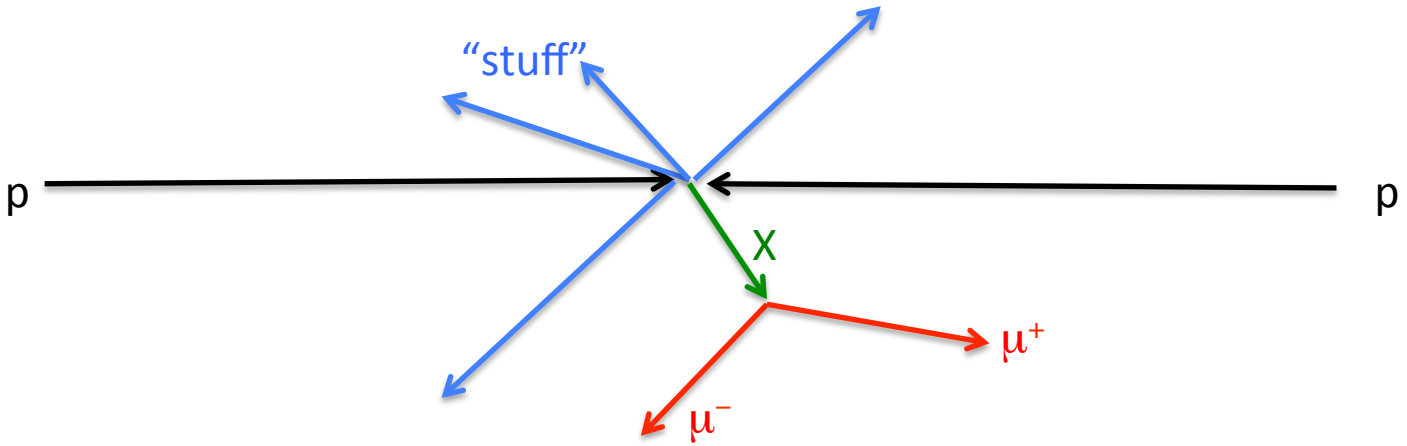
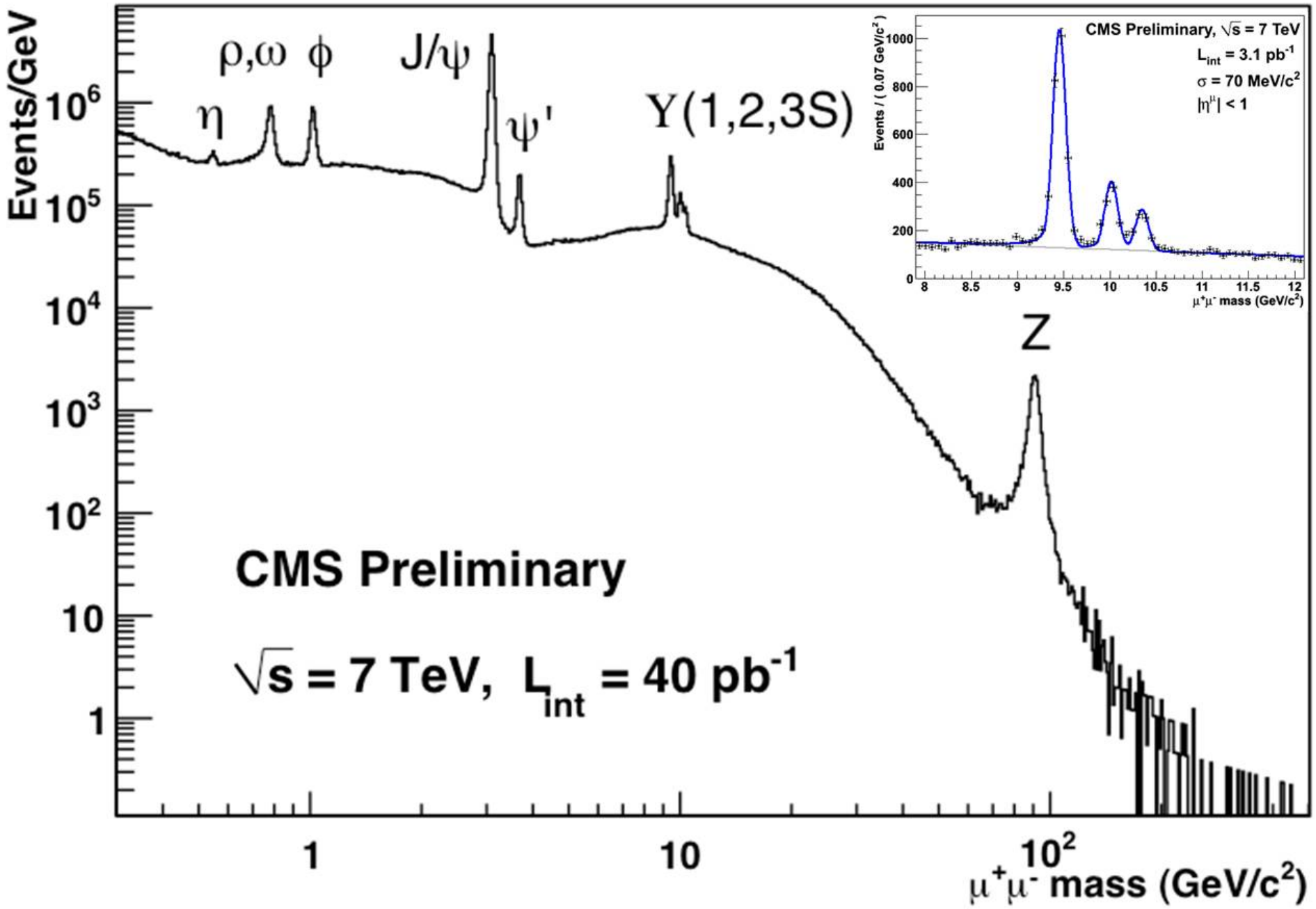
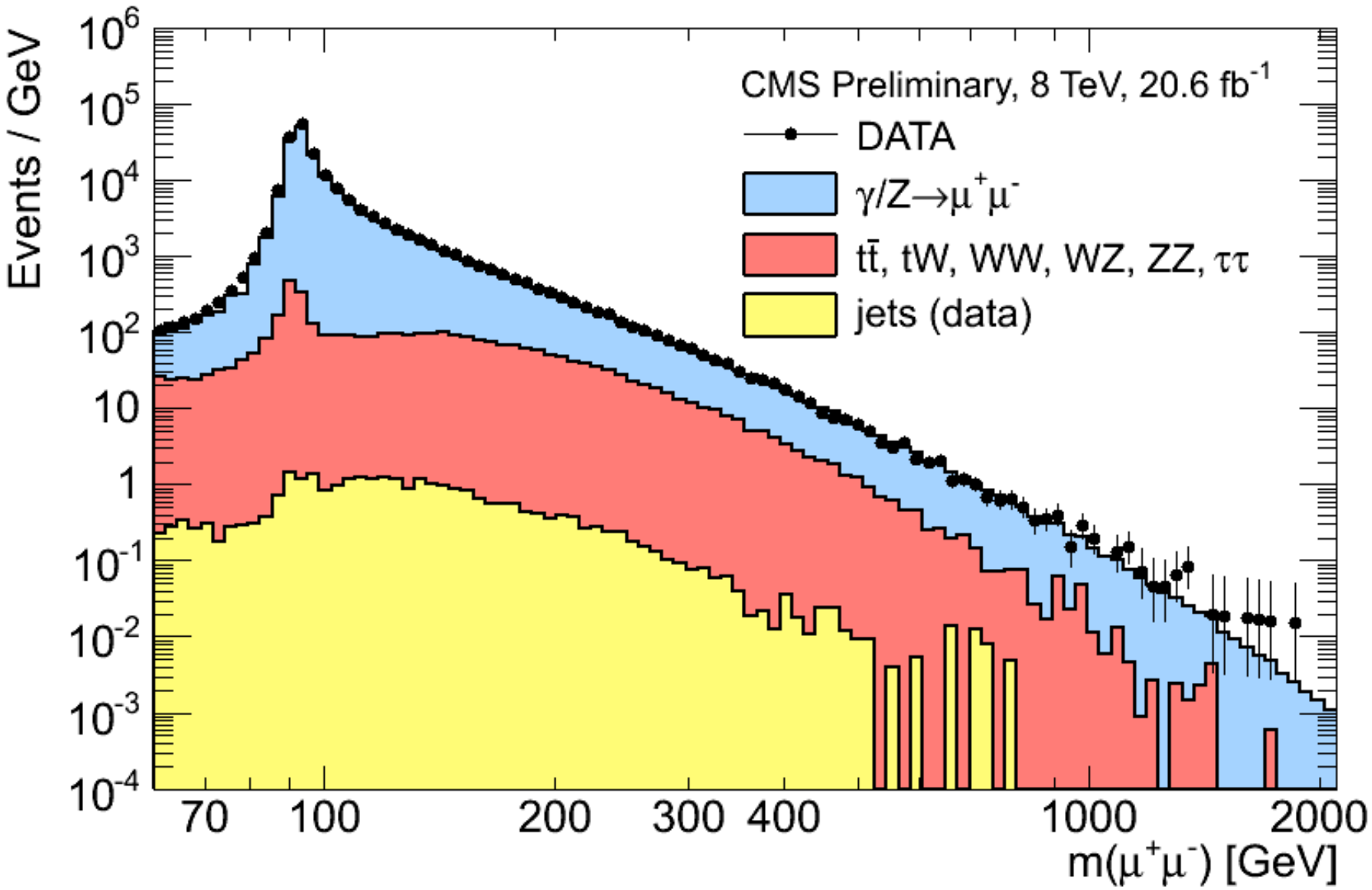
Large Hadron Collider at CERN. Collide two protons head on. Each proton has E = 3.5 TeV
Interested in process pp→X+stuff followed by X→$\mu^+\mu^-$.

- Select collisions where we detect a μ^+ and a μ^-.
- Measure the 3-momenta of both muons. Construct the 4-momentum from $E^2=P^2+M_\mu{}^2$.
- Add the two 4-momenta
- Take the square of the resulting 4-momentum. (This gives a number!)
- Take the square-root of the result
- If the two muons come from decay of X, this will be = M_X (within resolution effects)




Events/GeV
10^6
10^5
10^4
10^3
10^2
10
1
ρ,ω φ
η
J/ψ
ψ'
Υ(1,2,3S)
Z
CMS Preliminary
$\sqrt{s}$ = 7 TeV, L_{int} = 40 pb^{-1}
1
10
10^2
$\mu^+\mu^-$ mass (GeV/c^2)
CMS Preliminary, $\sqrt{s}$ = 7 TeV
L_{int} = 3.1 pb^{-1}
σ = 70 MeV/c^2
$|\eta^\mu|$ < 1
Events / (0.07 GeV/c^2)
1000
800
600
400
200
0
8
8.5
9
9.5
10
10.5
11
11.5
12
$\mu^+\mu^-$ mass (GeV/c^2)

More data……


CMS Preliminary, 8 TeV, 20.6 fb-1
DATA
γ/Z→μ+μ-
tt̄, tW, WW, WZ, ZZ, ττ
jets (data)
Events / GeV
m(μ+μ-) [GeV]
70
100
200
300
400
1000
2000

Same idea now, but look for the Higgs boson.

Two “decay channels”

1. $H \rightarrow \gamma\gamma$
2. $H \rightarrow \mu^+\mu^+\mu^-\mu^-$ or $\mu^+\mu^-e^+e^-$ or $e^+e^+e^-e^-$

TIME

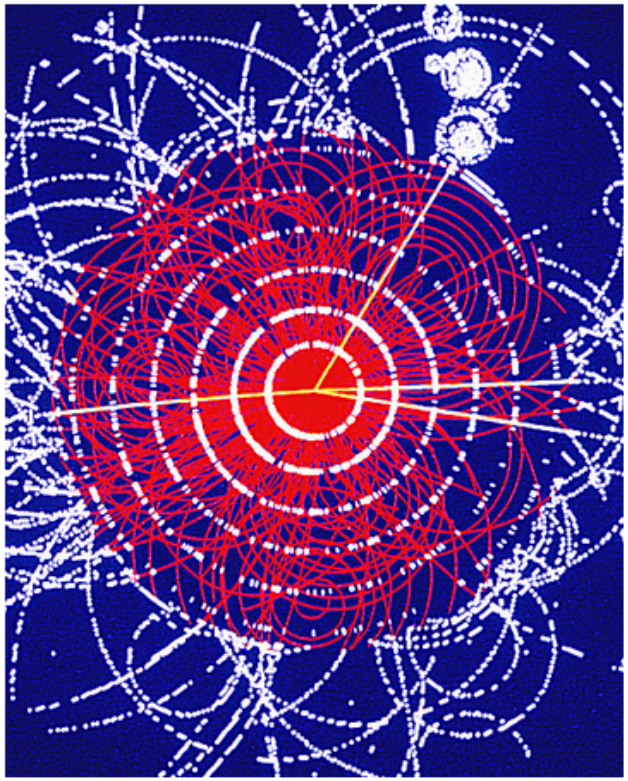
Person of the Year

THE CANDIDATES

The Higgs Boson

18 of 40

By Jeffrey Kluger | Monday, Nov. 26, 2012



SSPL/GETTY IMAGES

Simulation of a Higgs-Boson decaying into four muons, CERN, 1990.

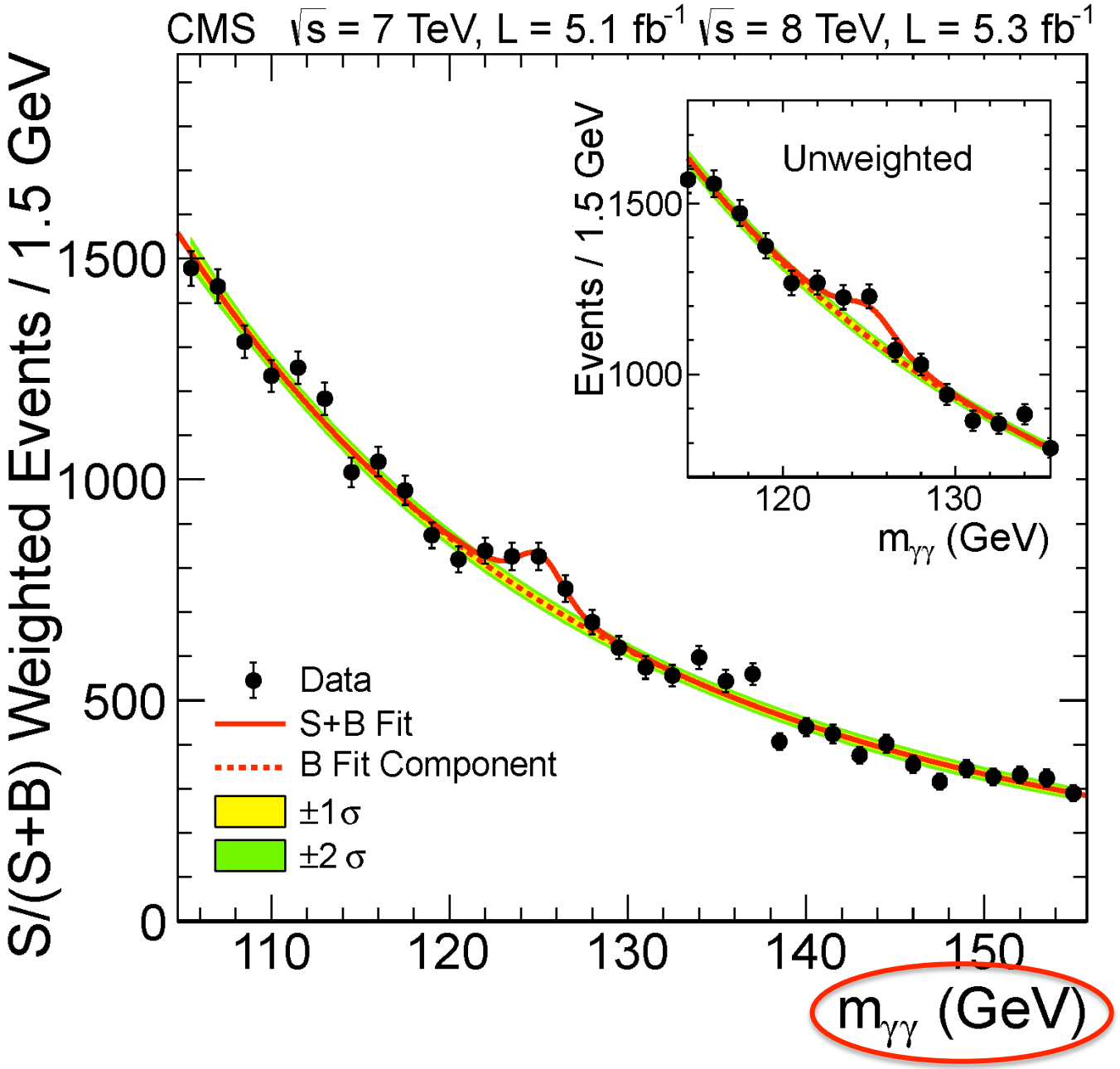
What do you think?

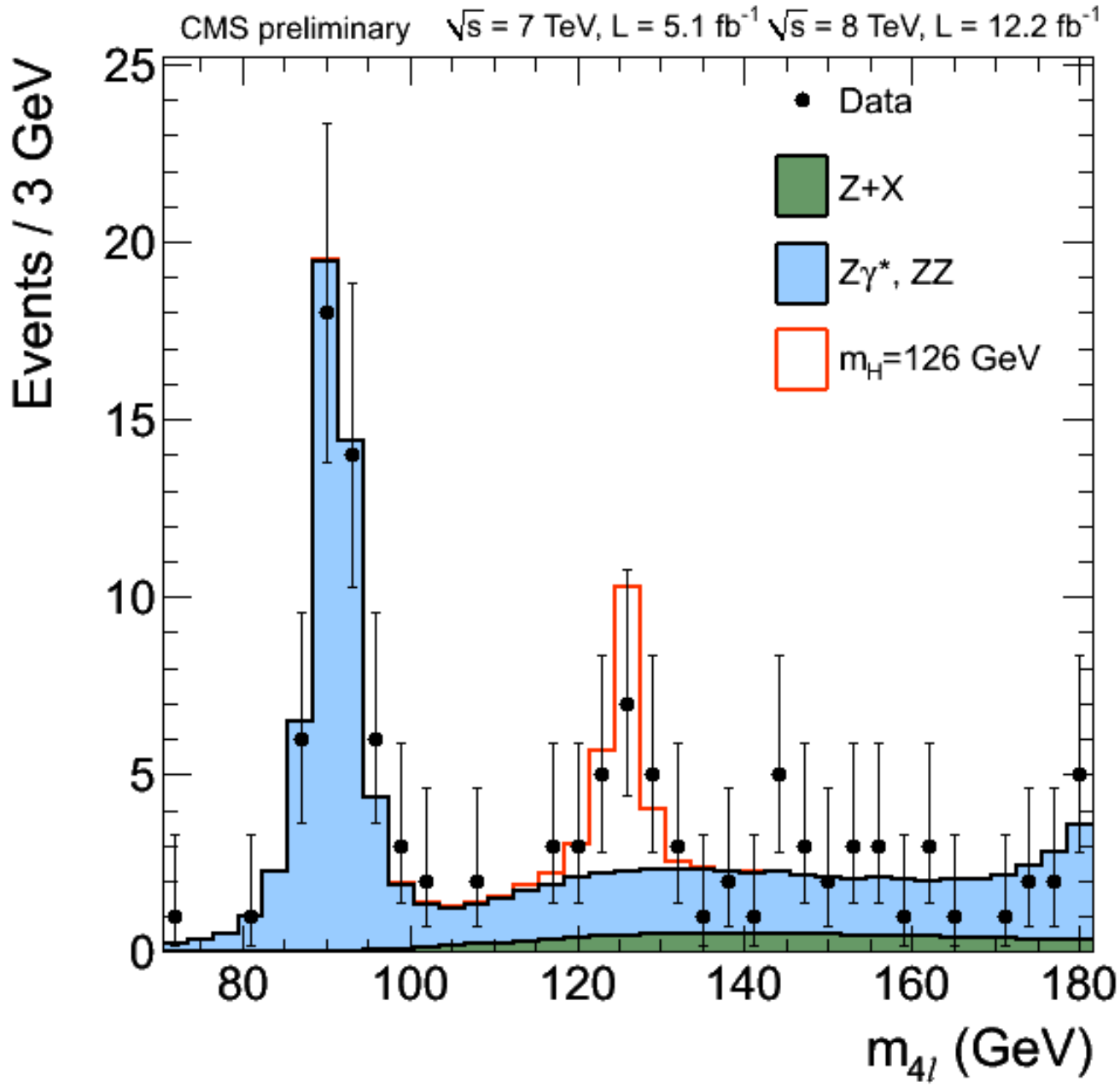
Should **The Higgs Boson** be TIME's Person of the Year 2012?

19.74% **Definitely** 80.26% **No Way**

Take a moment to thank this little particle for all the work it does, because without it, you'd be just inchoate energy without so much as a bit of mass. What's more, the same would be true for the entire universe. It was in the 1960s that Scottish physicist Peter Higgs first posited the existence of a particle that causes energy to make the jump to matter. But it was not until last summer that a team of researchers at Europe's Large Hadron Collider — Rolf Heuer, Joseph Incandela and Fabiola Gianotti — at last sealed the deal and in so doing finally fully confirmed Einstein's general theory of relativity. The Higgs — as particles do — immediately decayed to more-fundamental particles, but the scientists would surely be happy to collect any honors or awards in its stead.

Photos: Step inside the Large Hadron Collider.


CMS √s = 7 TeV, L = 5.1 fb-1 √s = 8 TeV, L = 5.3 fb-1
S/(S+B) Weighted Events / 1.5 GeV
0
500
1000
1500
110
120
130
140
150
mγγ (GeV)
Data
S+B Fit
B Fit Component
±1σ
±2 σ
Unweighted
Events / 1.5 GeV
1000
1500
120
130
mγγ (GeV)


CMS preliminary
√s = 7 TeV, L = 5.1 fb-1 √s = 8 TeV, L = 12.2 fb-1
Data
Z+X
Zγ*, ZZ
mH=126 GeV
Events / 3 GeV
m4l (GeV)
0
5
10
15
20
25
80
100
120
140
160
180