Electroweak unification

Forces Merge at High Energies
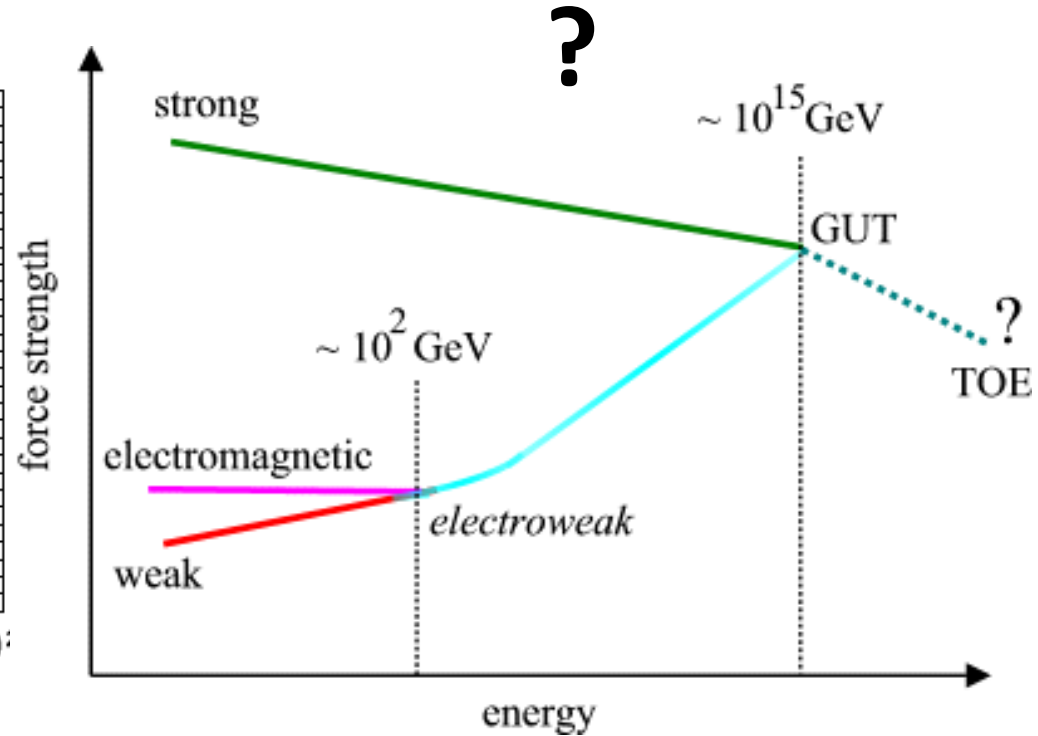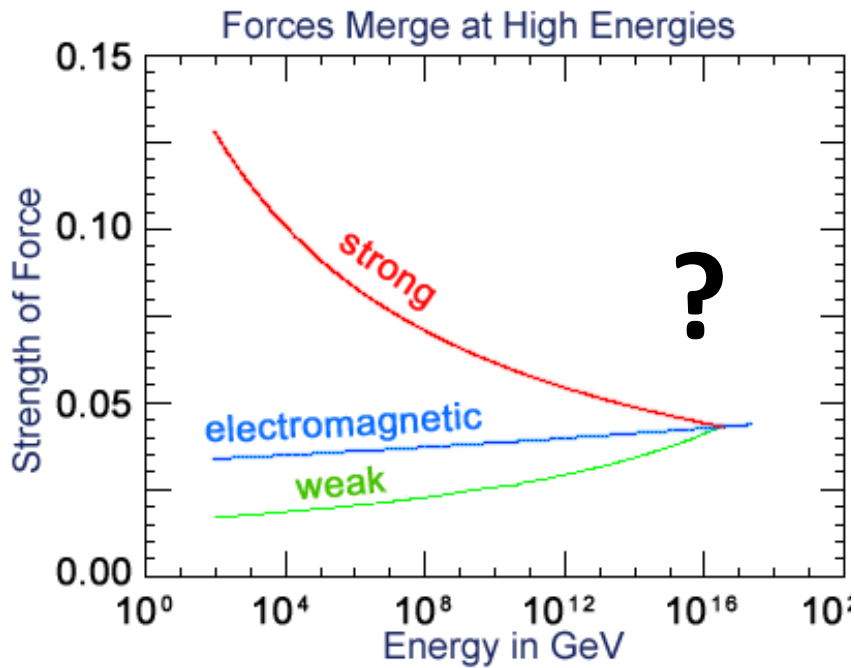
Massive problem...

Experiment

$$m_e = 510.9989\,keV$$

$$\frac{m_w}{m_z} = \frac{80.425 \pm 0.038}{91.188 \pm 0.002}\,GeV$$

$$= 0.8820 \pm 0.0004$$

Theory

$$m_e = 0$$

$$\frac{m_w}{m_z} = 0$$

extended theory
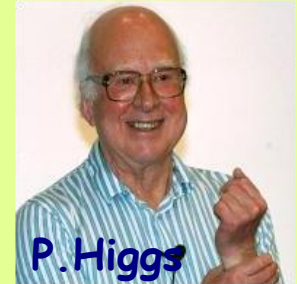
$$m_e = \ldots > 0$$

$$\frac{m_w}{m_z} = \frac{\ldots > 0}{\ldots > 0}$$

P. Higgs

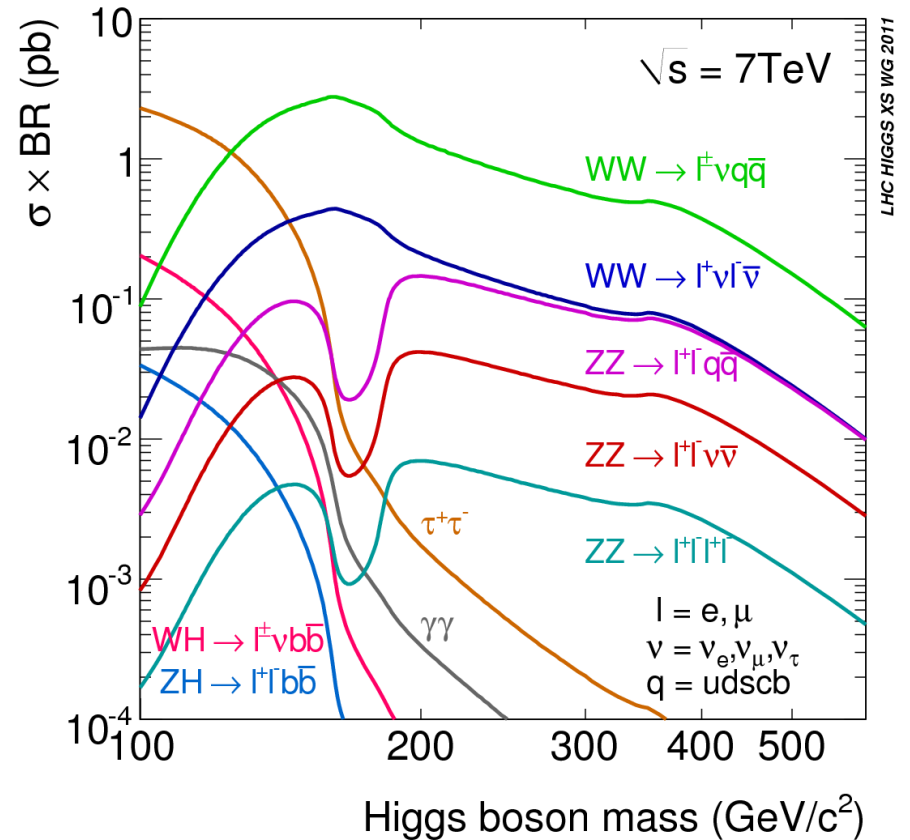$$= 0.8812 \pm 0.0014$$

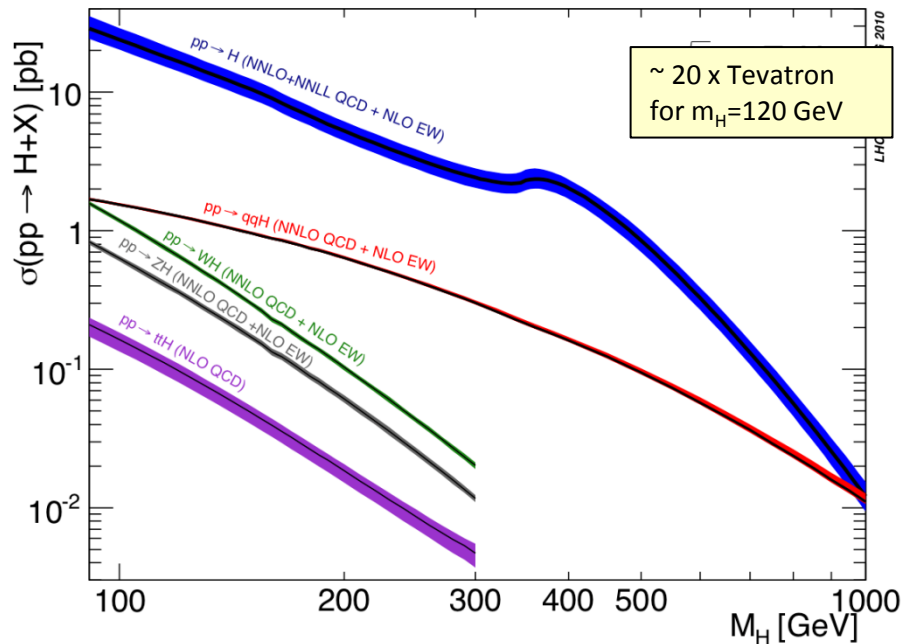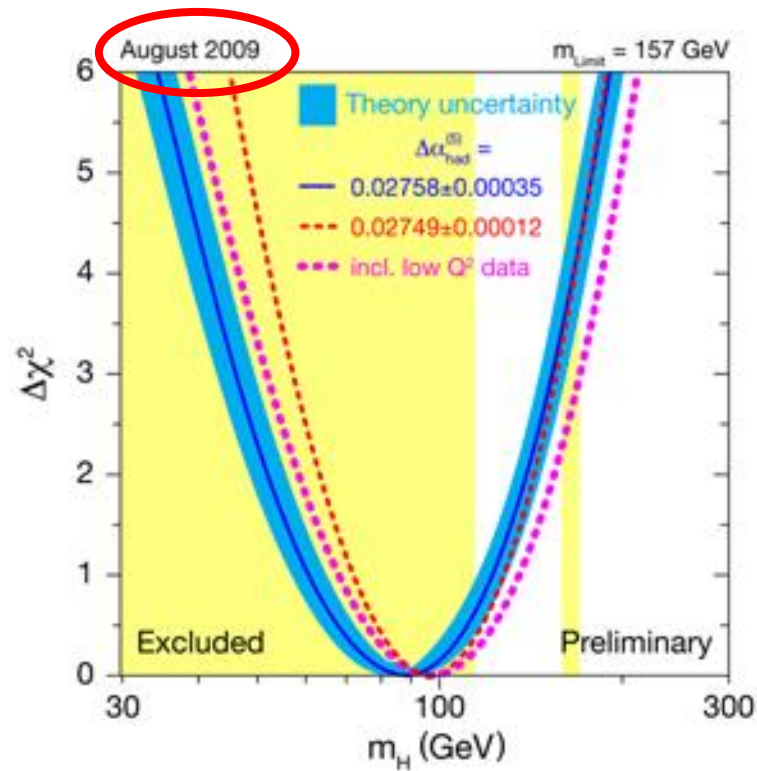**The Higgs mechanism illustrated:**

Particle in higgs field

Higgs particle

Higgs production and decay
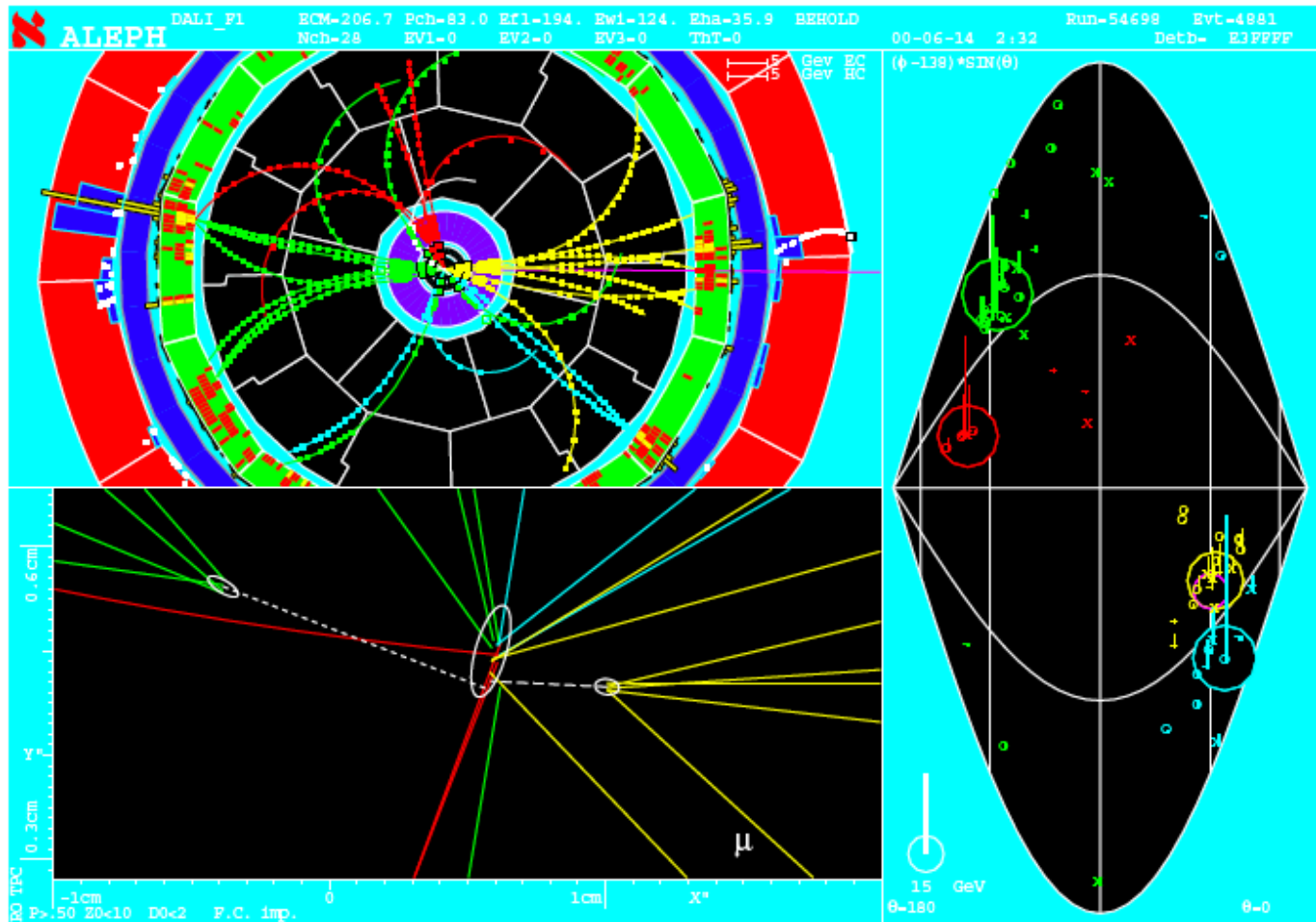
Constraints on the Higgs mass from LEP and Tevatron

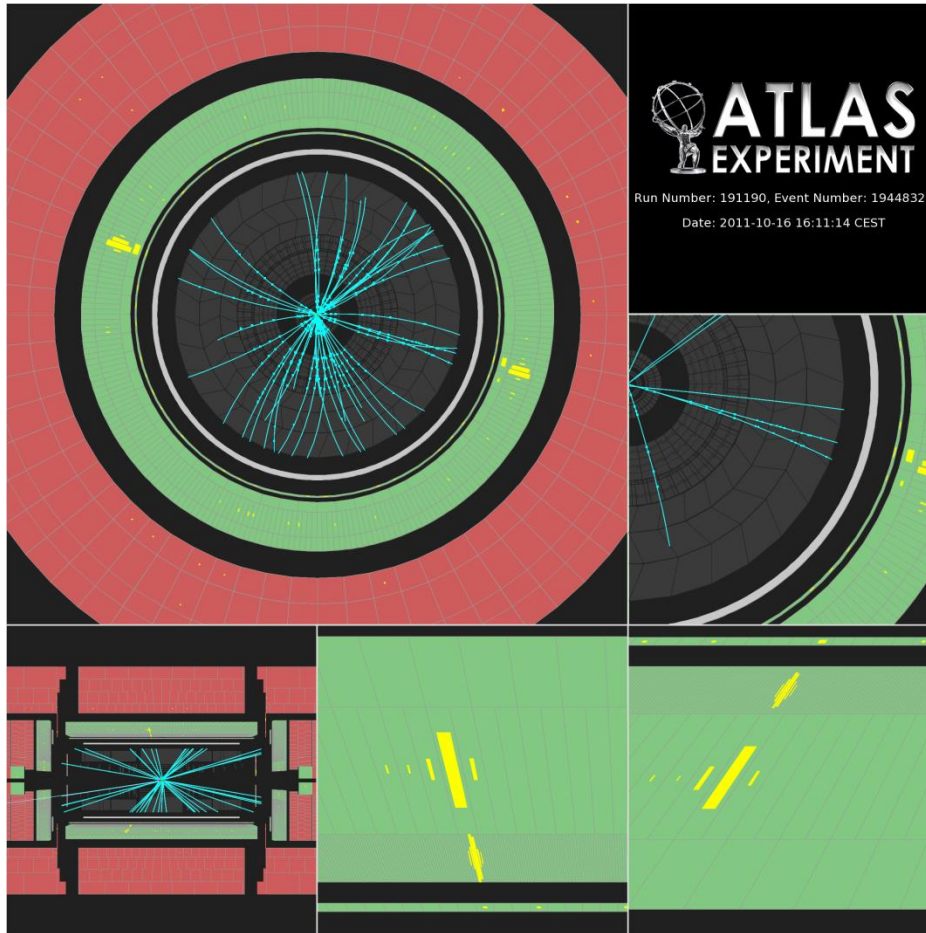(assuming there is nothing else than the Standard Model)

http://lepewwg.web.cern.ch/LEPEWWG/
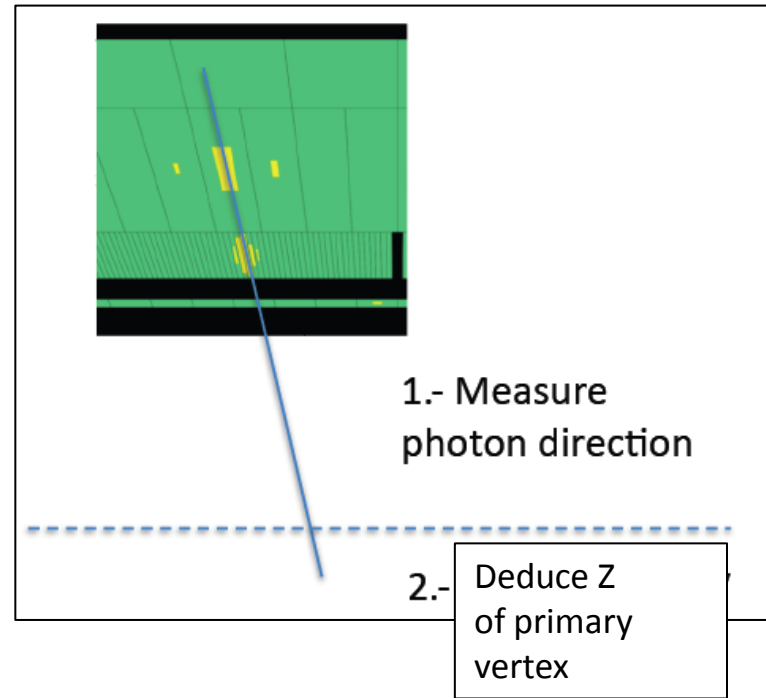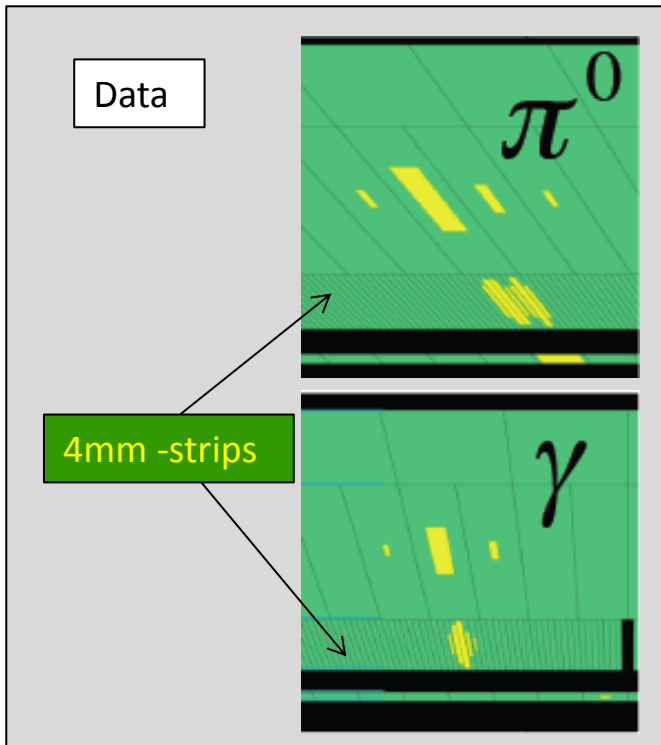
A LEP Higgs boson?

H → γγ candidate

$$m^2_{\gamma\gamma} = 2\, E_1\, E_2\, (1 - \cos\alpha)$$

γ vs π^0

Data

π^0

γ

4mm -strips

1.- Measure photon direction

2.- Deduce Z of primary vertex

Bump hunting

(a) 95% CL Limit on μ

ATLAS 2011 - 2012

$\sqrt{s}$ = 7 TeV: $\int Ldt$ = 4.6-4.8 fb^{-1}
$\sqrt{s}$ = 8 TeV: $\int Ldt$ = 5.8-5.9 fb^{-1}

$\pm 1\sigma$
$\pm 2\sigma$
Observed
Bkg. Expected

CL$_s$ Limits

(b) Local p_0

Sig. Expected
Observed

2σ
3σ
4σ
5σ
6σ

(c) Signal strength (μ)

Observed
-2 ln $\lambda(\mu)$<1

m_H [GeV]
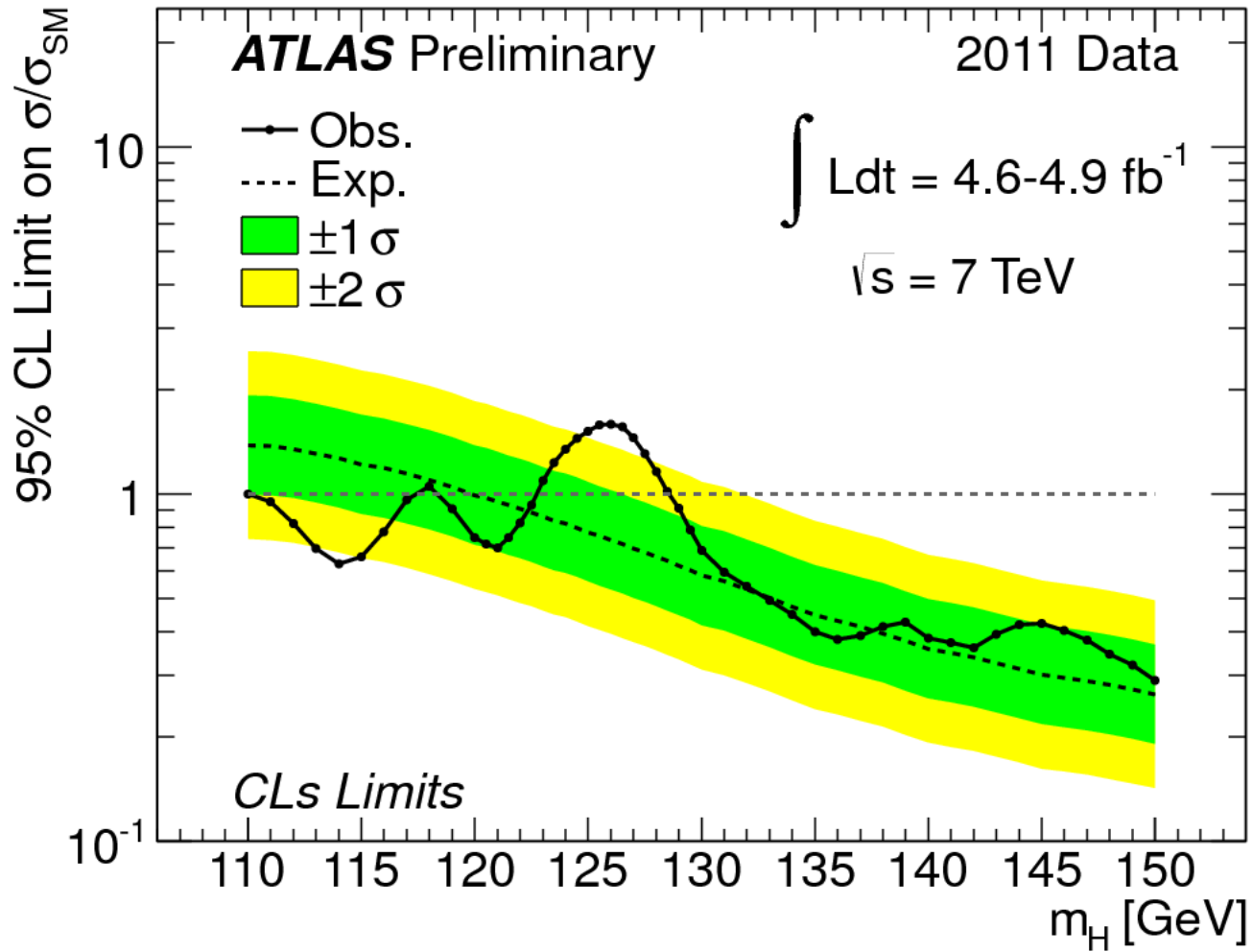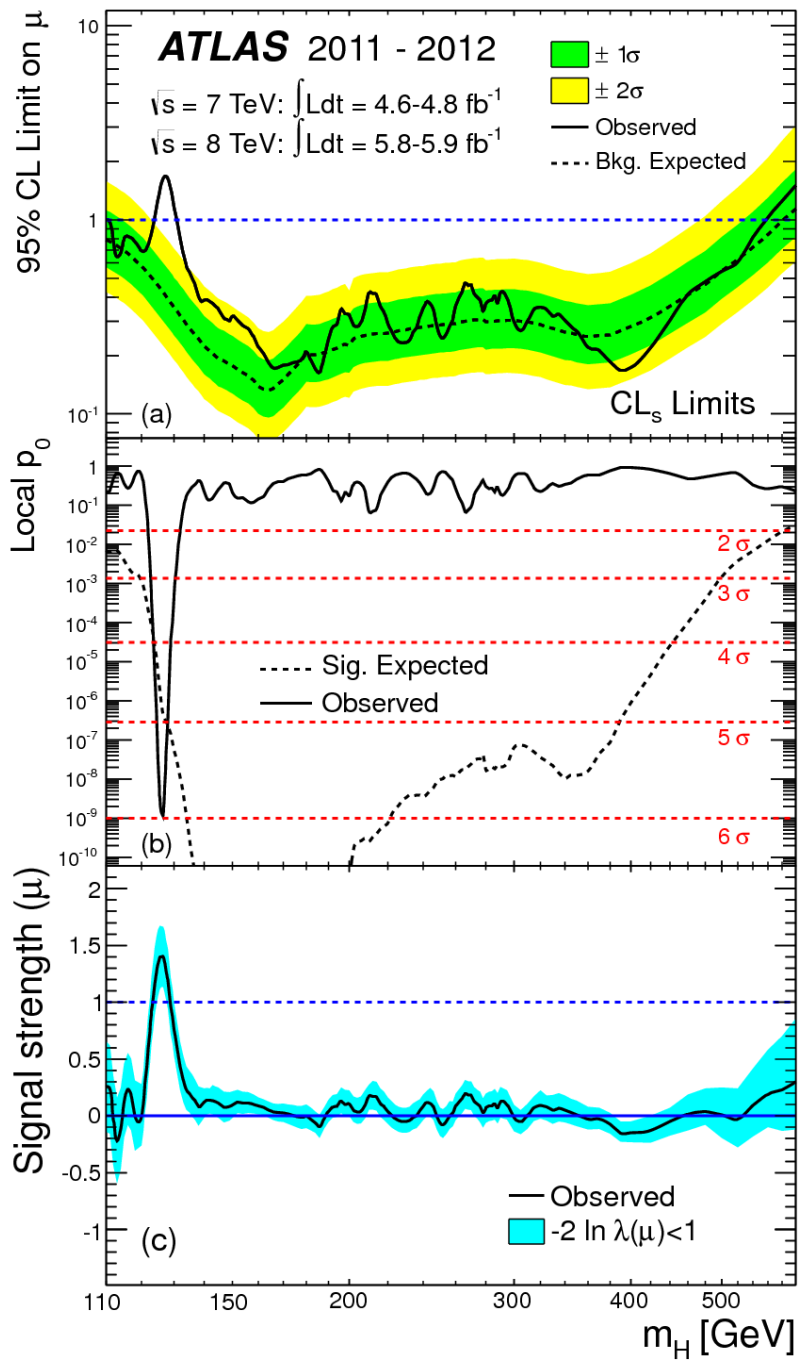
A discovery

Higgs → ZZ candidate

H → WW candidate

H → WW angle

Left figure:

Events / 5 GeV

35

30

25

20

15

10

5

$\sqrt{s}$ = 7 TeV $\int$ Ldt = 0.05 fb^{-1} Apr 24, 2011

ATLAS Preliminary

H→ZZ$^{(*)}$→4l channel

Signal (m$_H$=125 GeV)

Background ZZ$^{(*)}$

Background Z+jets, t$\bar{t}$

Data

Data - Background

10

0

-10

50   100   150   200   250   300   350   400   450   500

M$_{4l}$ [GeV]

Right figure:

Events / 10 GeV

450

400

350

300

250

200

150

100

50

0

ATLAS Preliminary

$\sqrt{s}$ = 8 TeV, $\int$ Ldt = 0.0 fb^{-1}

H→WW$^{(*)}$→ eνμν with 0/1 jet

Data

WW

WZ/ZZ/Wγ

t$\bar{t}$

Single Top

Z+jets

W+jets

H [125 GeV]

06.04.2012

Data-Background

50

40

30

20

10

0

-10

-20

50   100   150   200   250   300

m$_T$ [GeV]
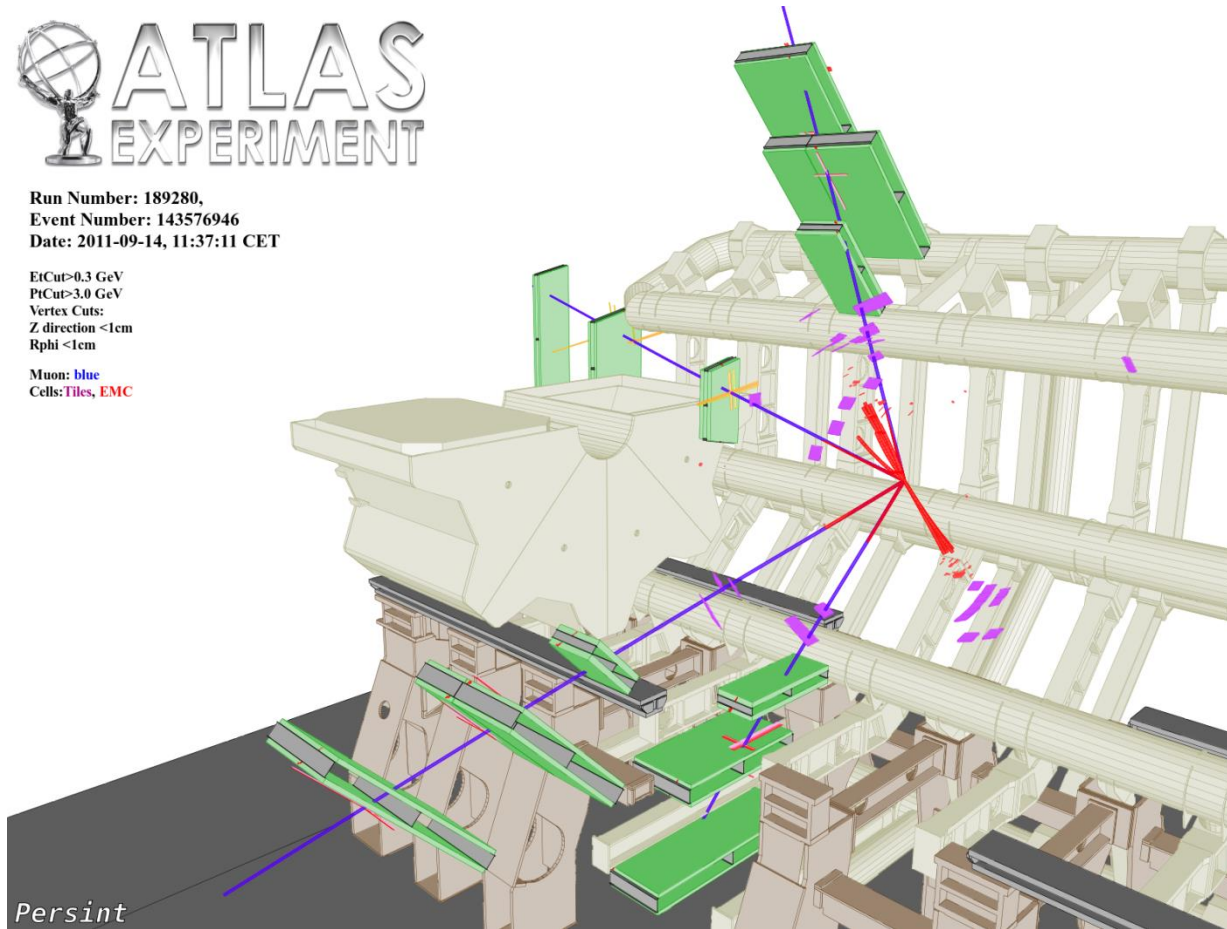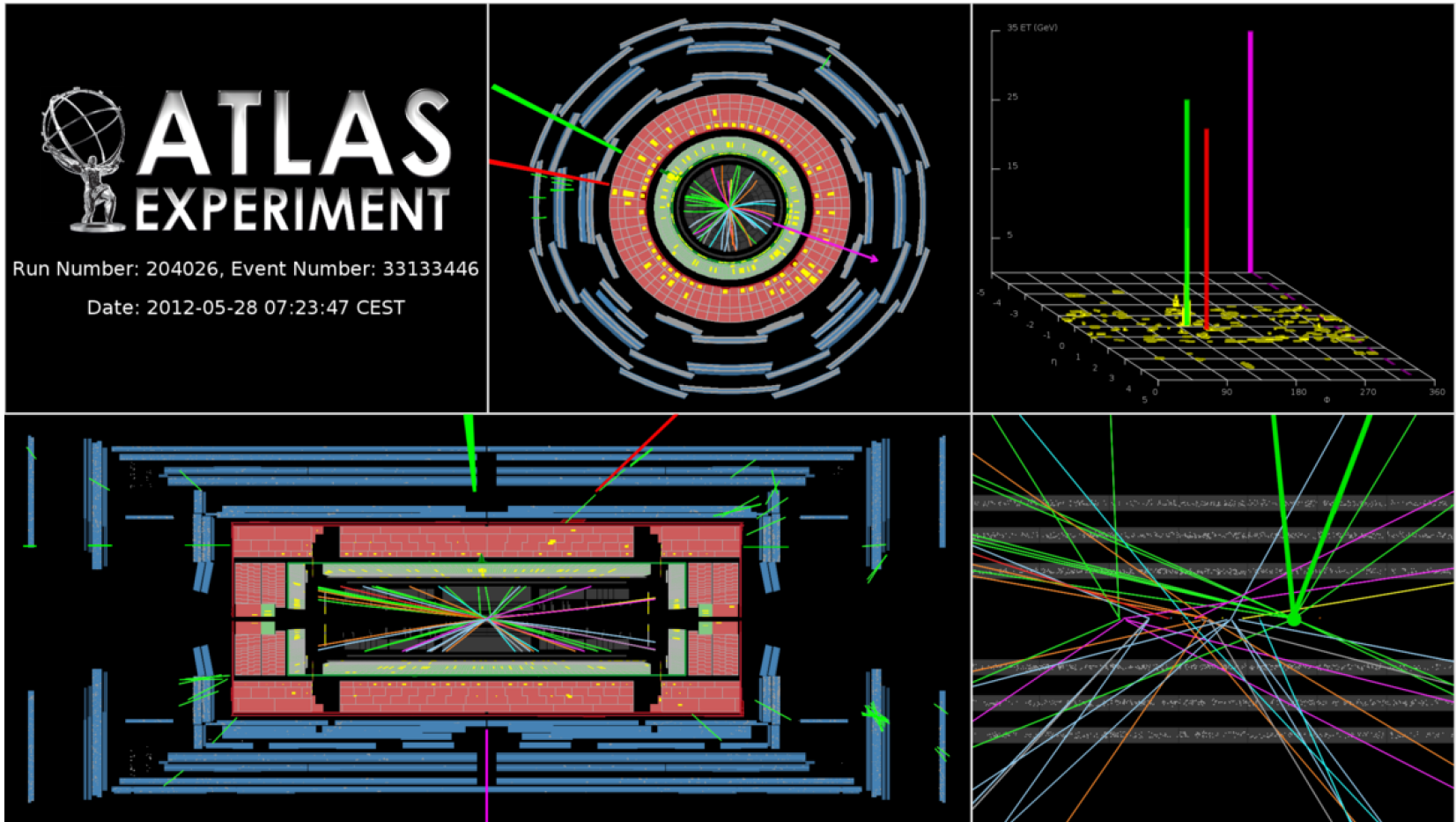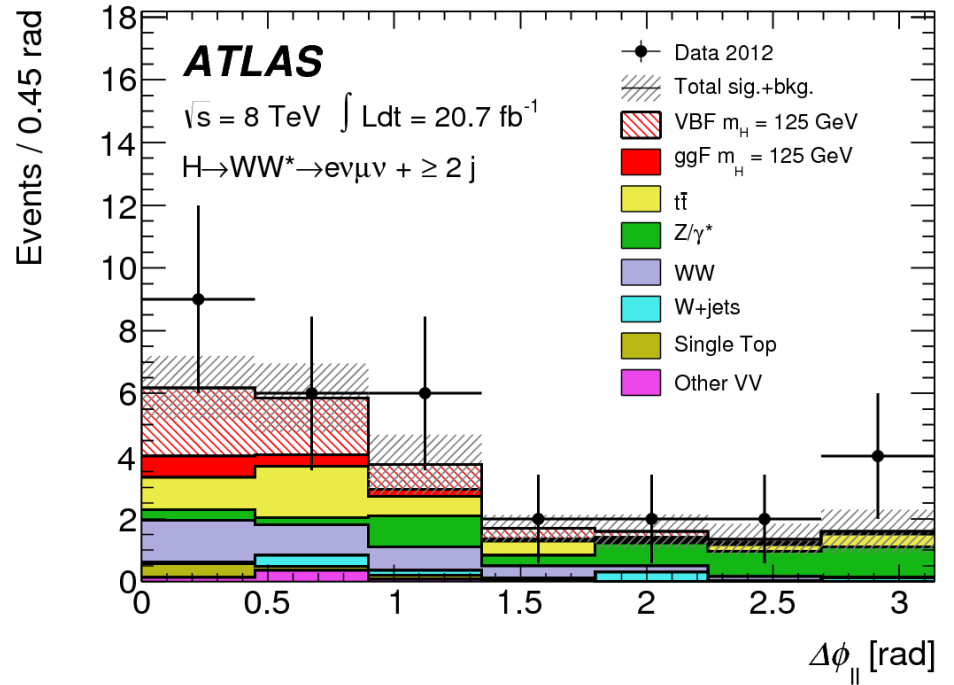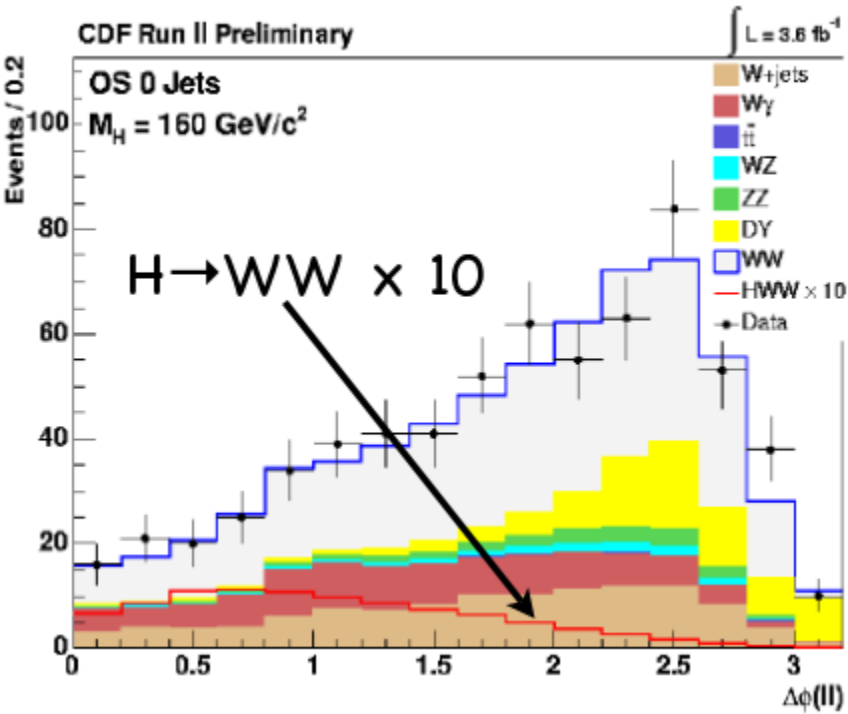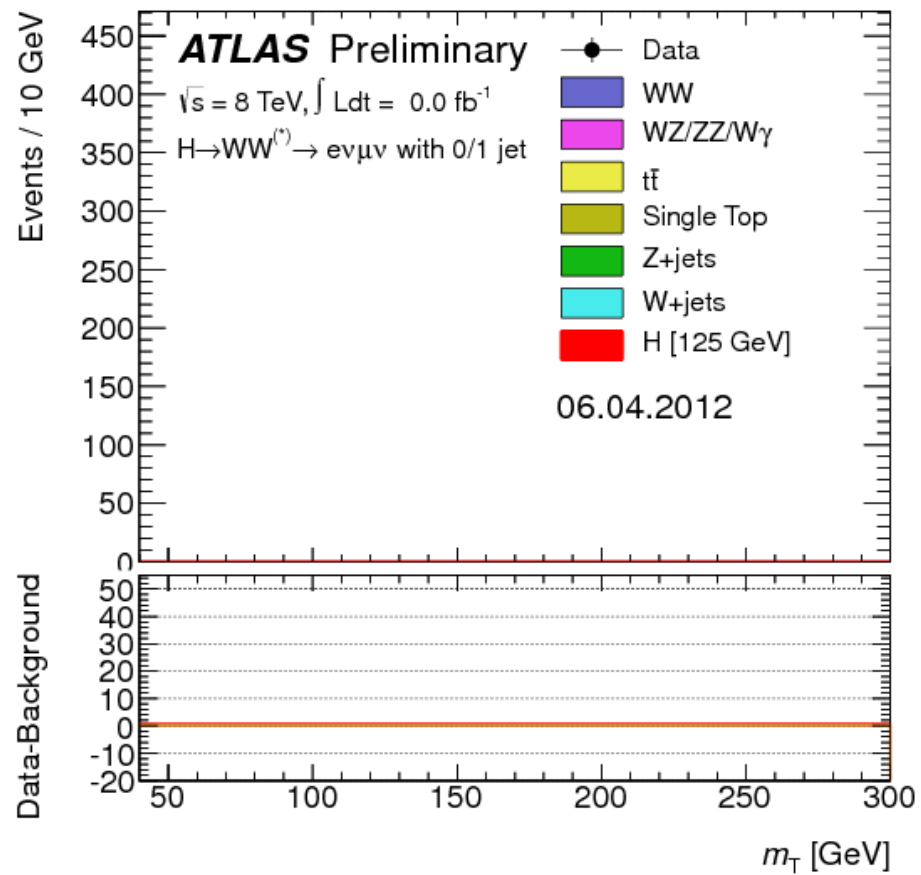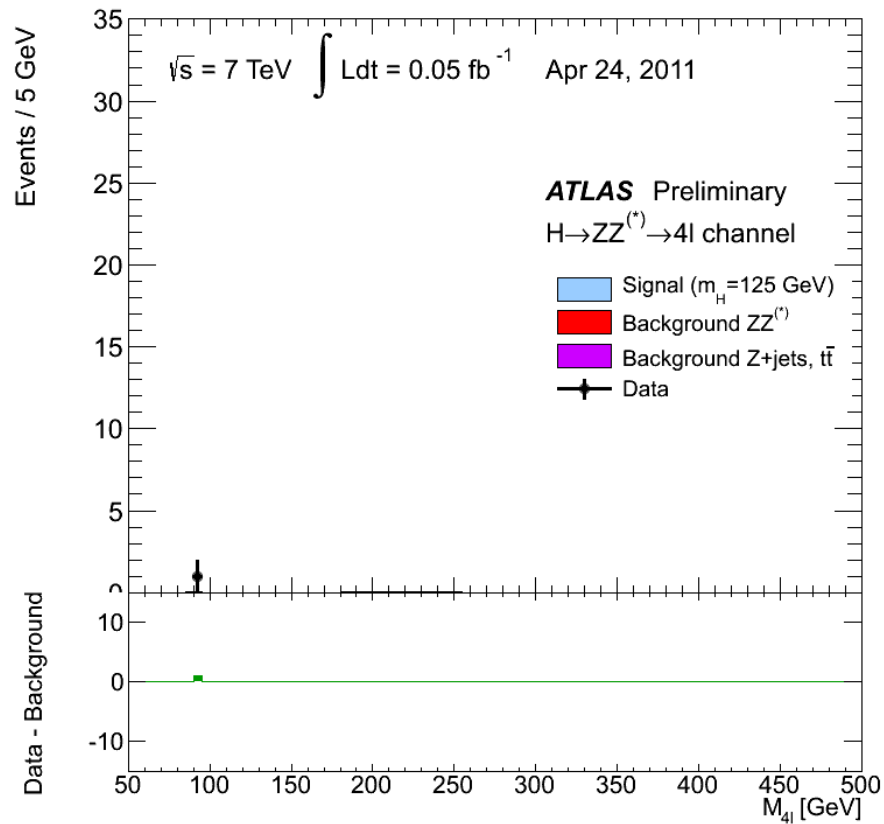
Higgs couplings to dibosons

Spinless particle?