

# Physique aux collisionneurs

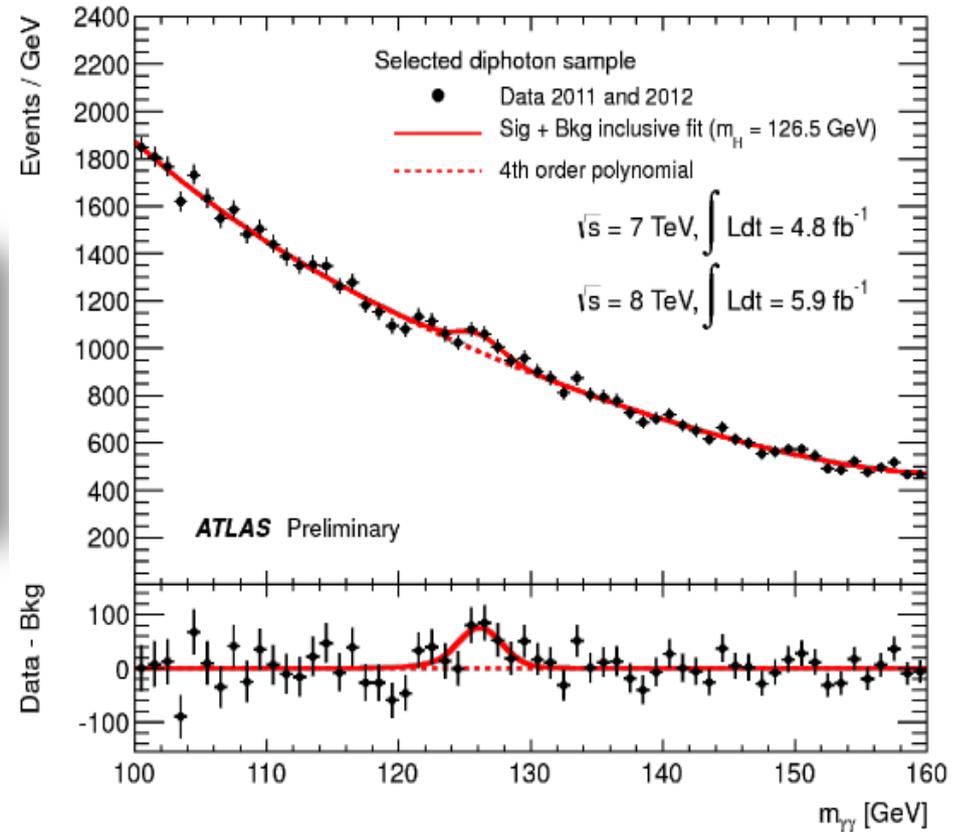
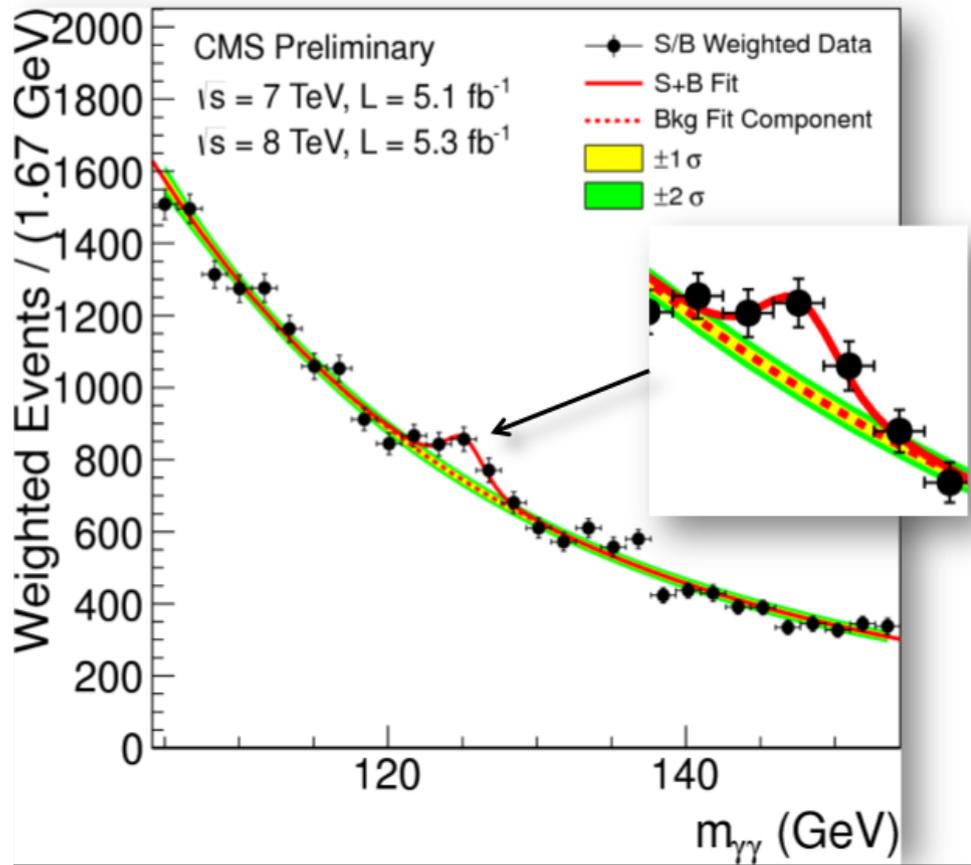
## Status de la brisure de symétrie électrofaible, à l'été 2012

Découverte du Higgs (?), désintégrations rares, paramètres électrofaibles :

Impact sur la nouvelle physique

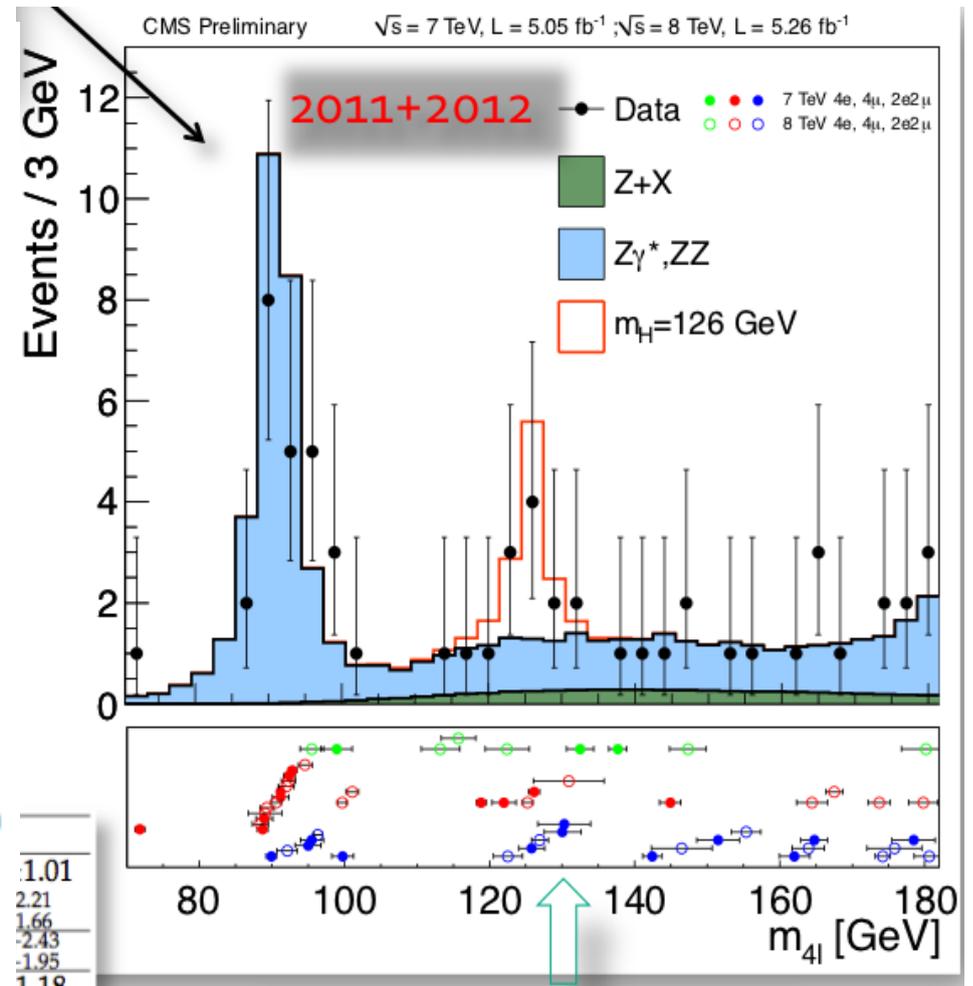
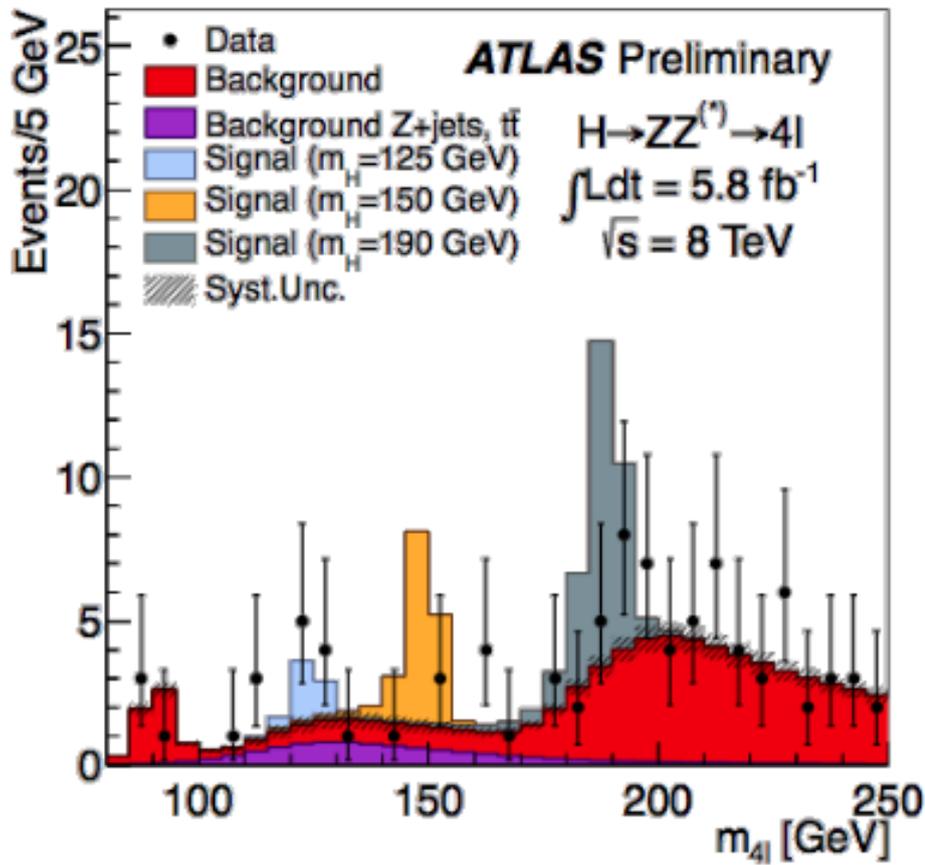
# Le boson de Higgs

- Découverte



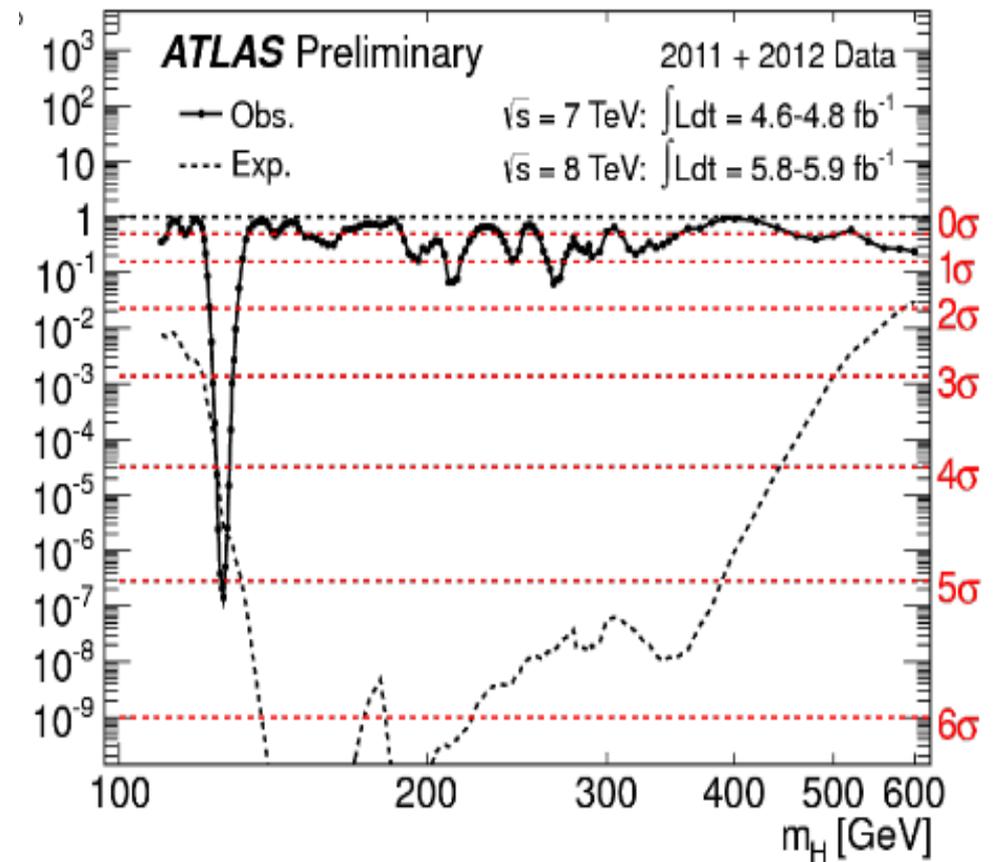
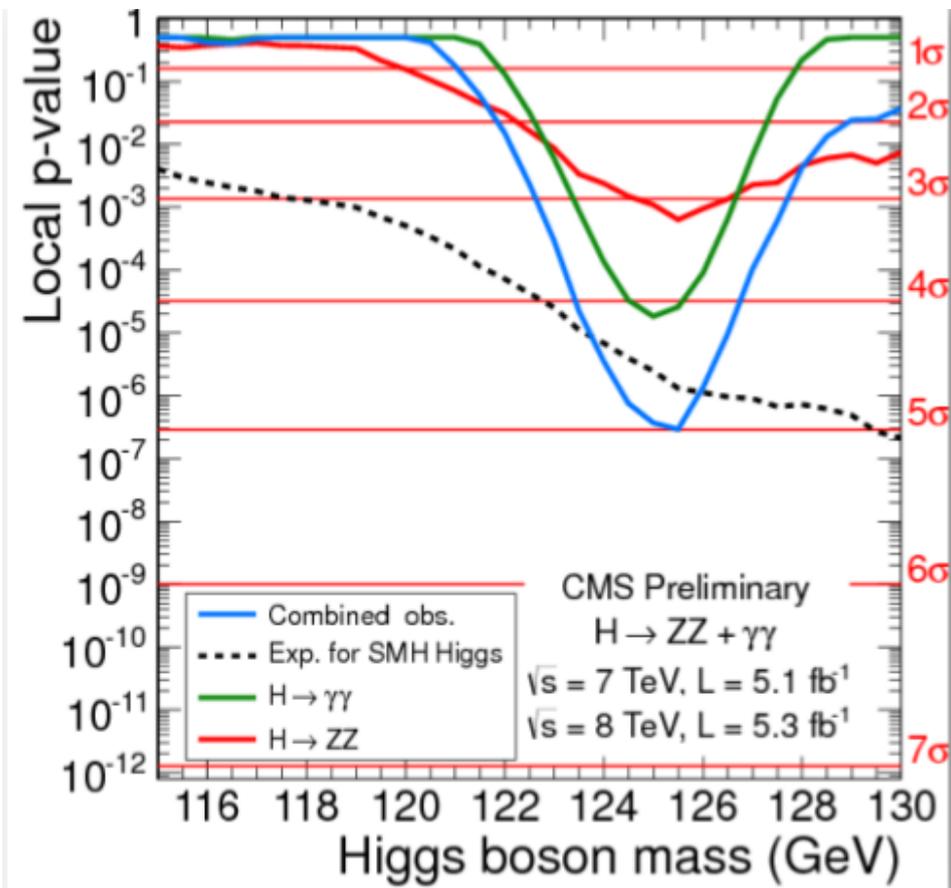
# Le boson de Higgs

- Découverte



# Le boson de Higgs

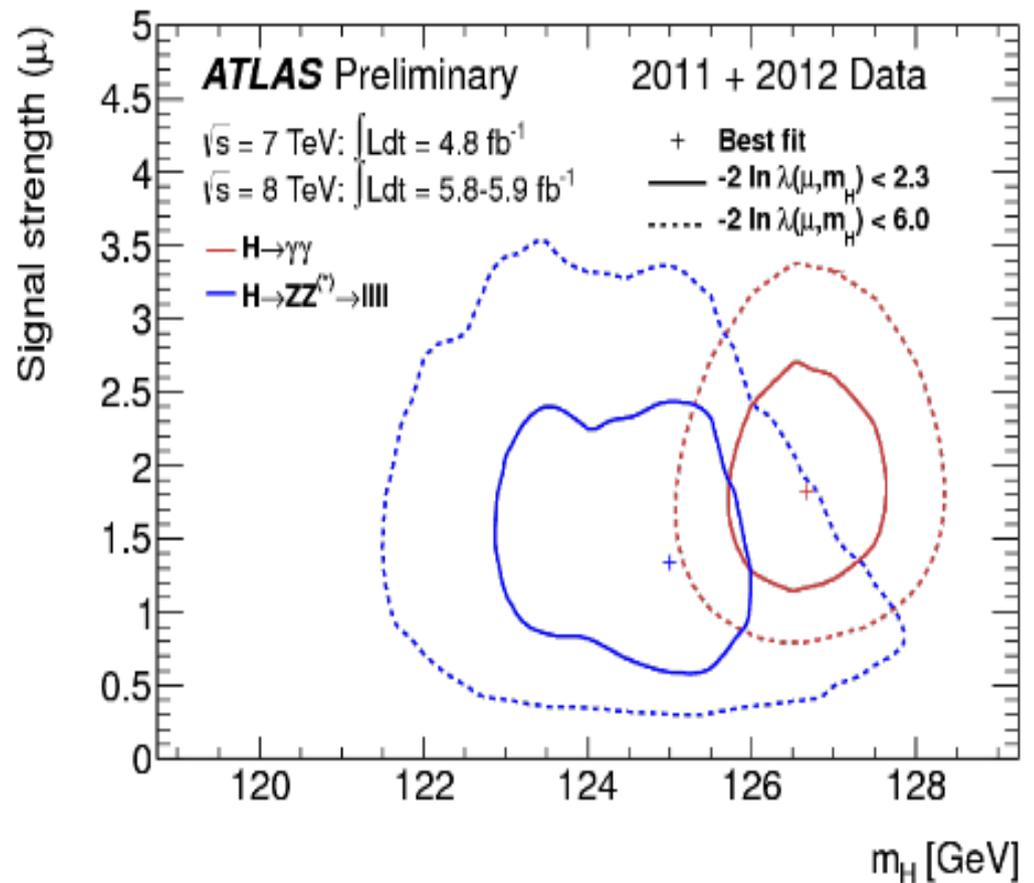
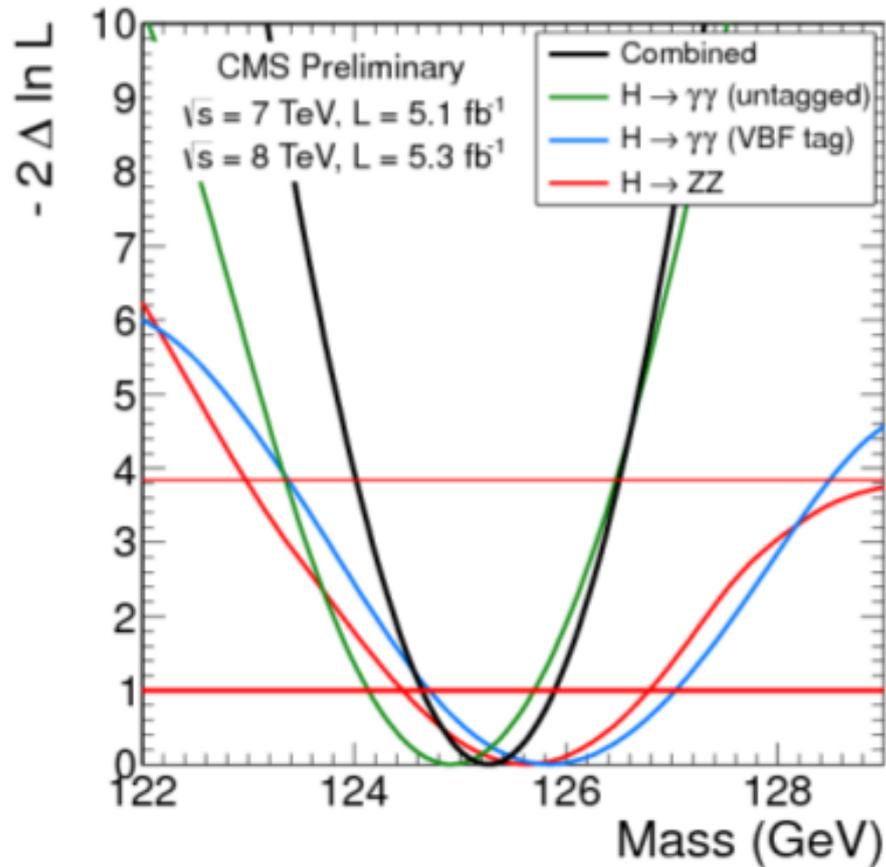
- Découverte
  - ➔ Un peu plus rapide que prévu



# Le boson de Higgs

- Propriétés

- ➔ Couplages un peu forts...

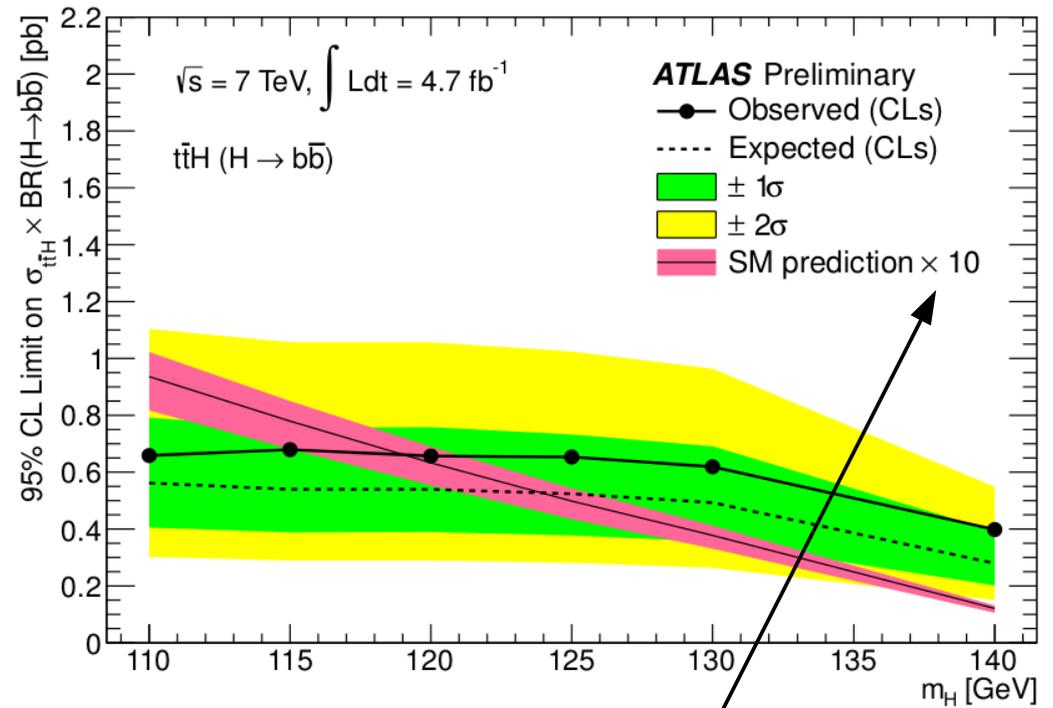
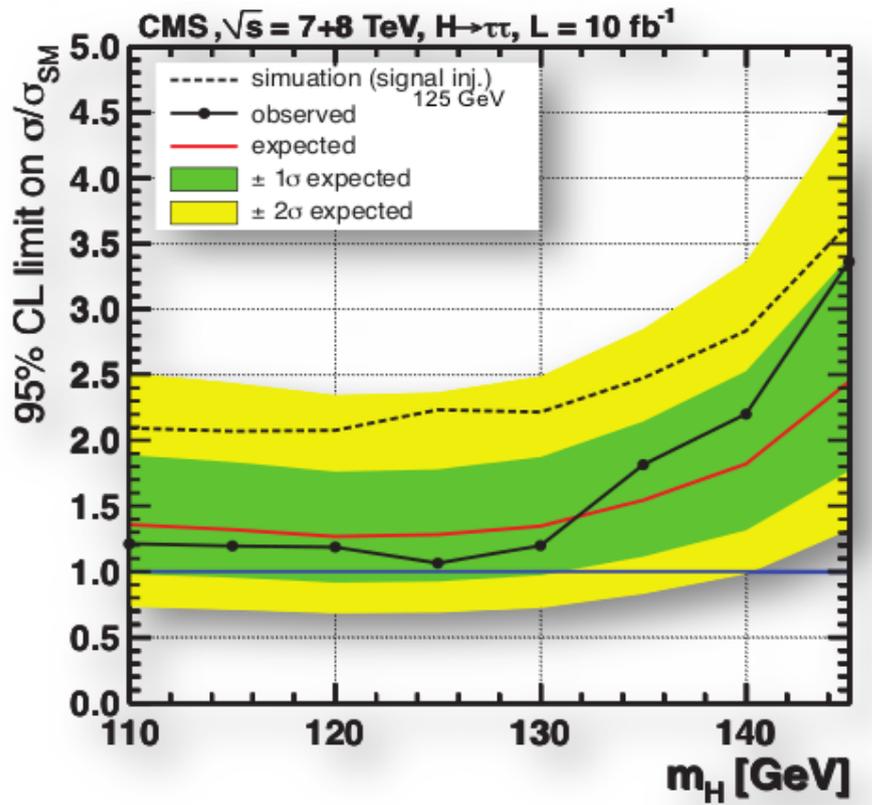


# Le boson de Higgs

- Propriétés

- ➔ Couplages aux fermions?

- ➔  $H \rightarrow \tau\tau$  "exclu" (CMS),  $H \rightarrow t\bar{t}$  insuffisamment sensible (ATLAS)

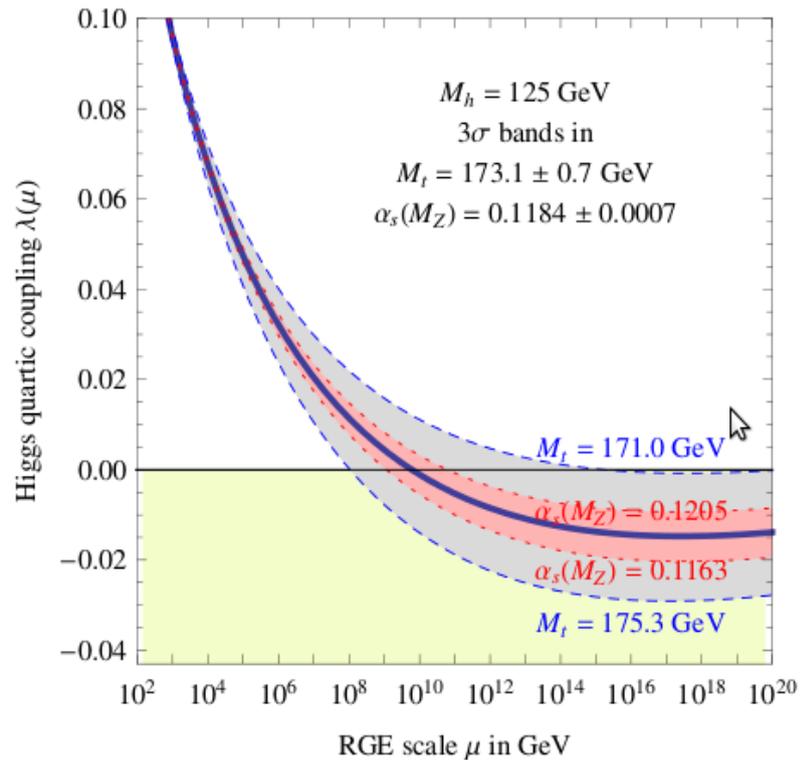
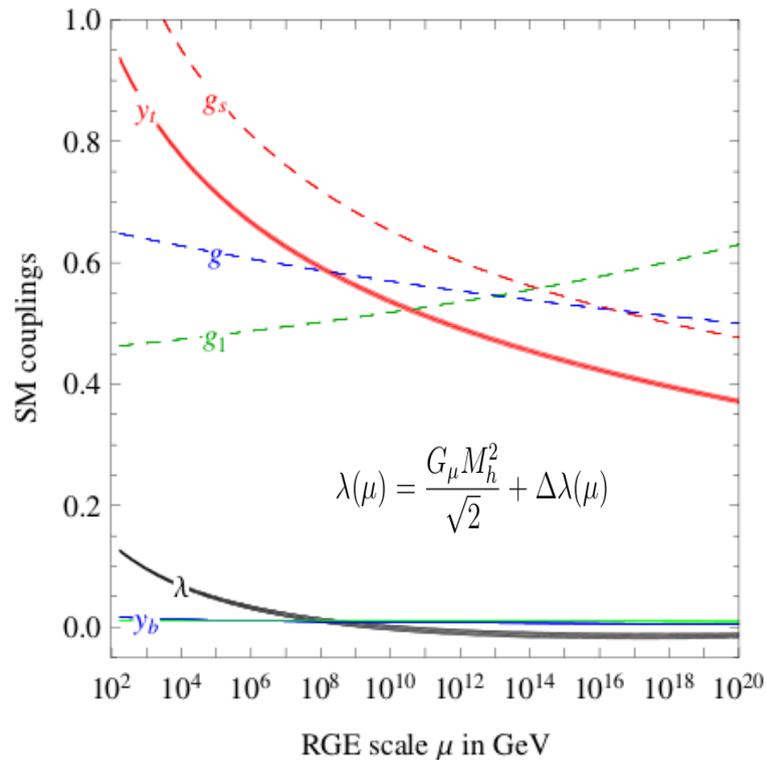


Comme au Tevatron :)

- ➔ Mise à jour des résultats pour HCP (~1 mois) : doublement de la statistique

# Implication pour le MS

- Domaine de validité du MS



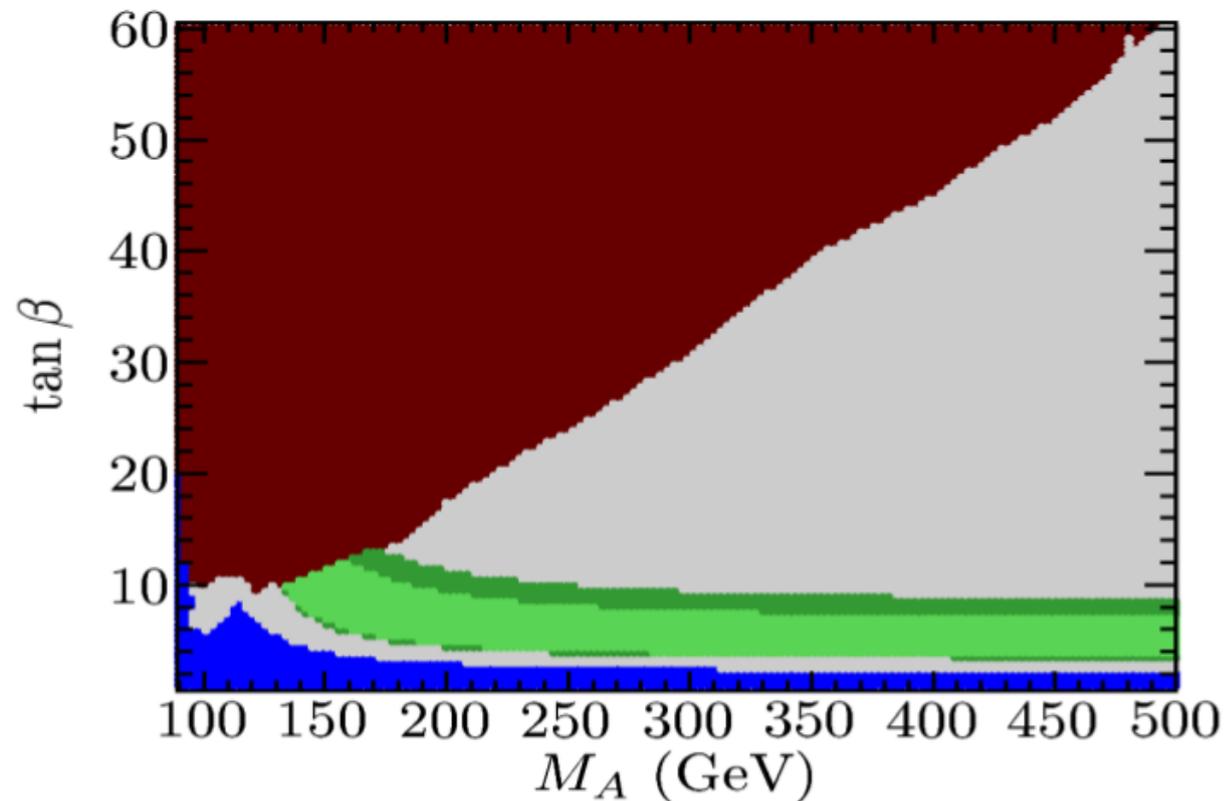
- ➔ Condition de stabilité à  $M_{\text{PLANCK}}$

$$M_h [\text{GeV}] > 129.4 + 1.4 \left( \frac{M_t [\text{GeV}] - 173.1}{0.7} \right) - 0.5 \left( \frac{\alpha_s(M_Z) - 0.1184}{0.0007} \right) \pm 1.0_{\text{th}} .$$

$$M_h > 129.4 \pm 1.8 \text{ GeV} .$$

# Implications pour SUSY : secteur de Higgs

- Contraintes  $m_A / \tan\beta$  : la piste la plus concrète pour chercher au-delà du MS
  - ➔ “ $m_h^{\max}$ ”  $\sim 125$  GeV :  $3 < \tan\beta < 10$ ,  $M_A > 130$  GeV,  $M_{H^\pm} > 150$  GeV

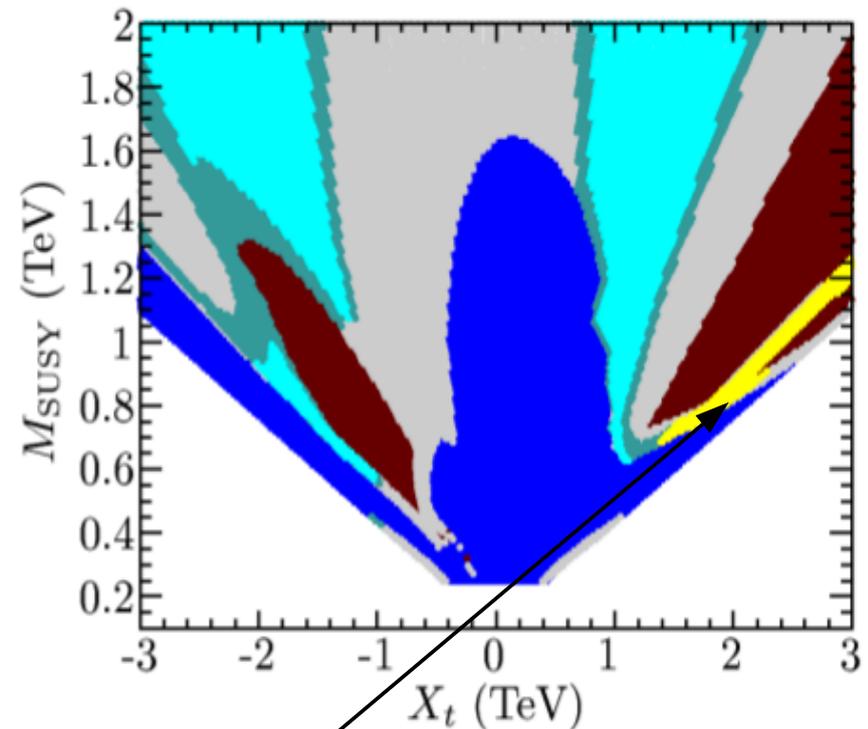
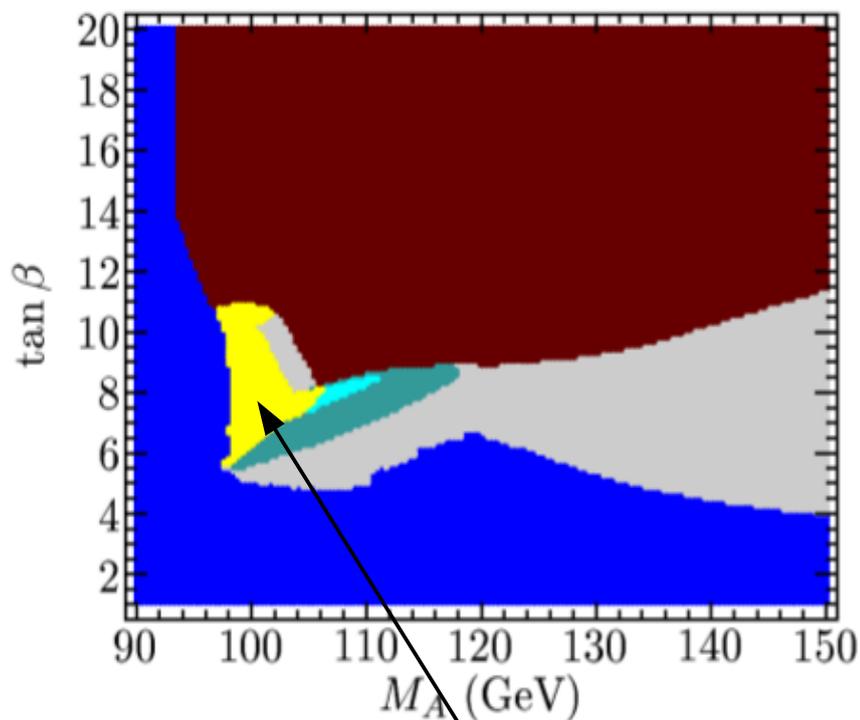


(le style de la figure marque un recul conceptuel!)

# Implications pour SUSY : secteur de Higgs

- Contraintes  $m_A / \tan\beta$  : la piste la plus concrète pour chercher au-delà du MS

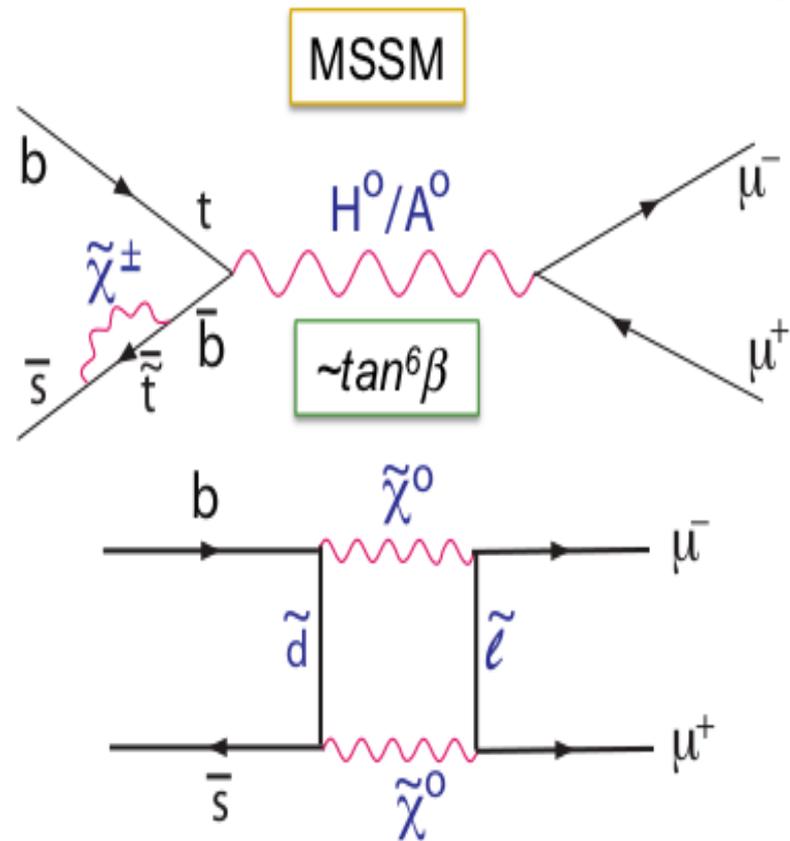
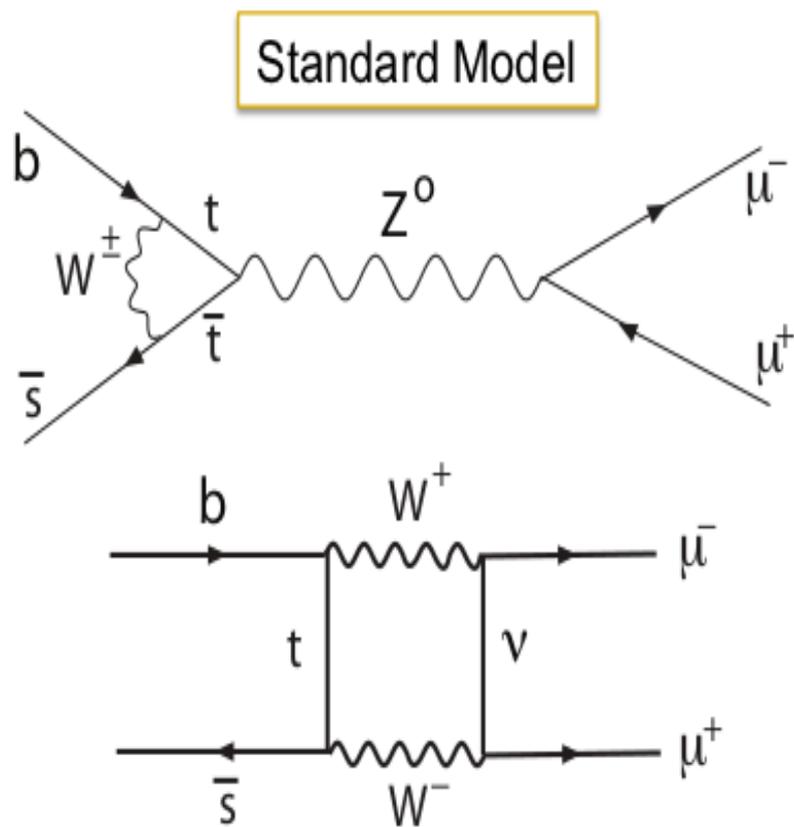
→  $M_H = 125$  GeV



Autorisé par  $\sigma(H \rightarrow \gamma\gamma) / \sigma_{\text{SM}}(H \rightarrow \gamma\gamma) \sim 1$

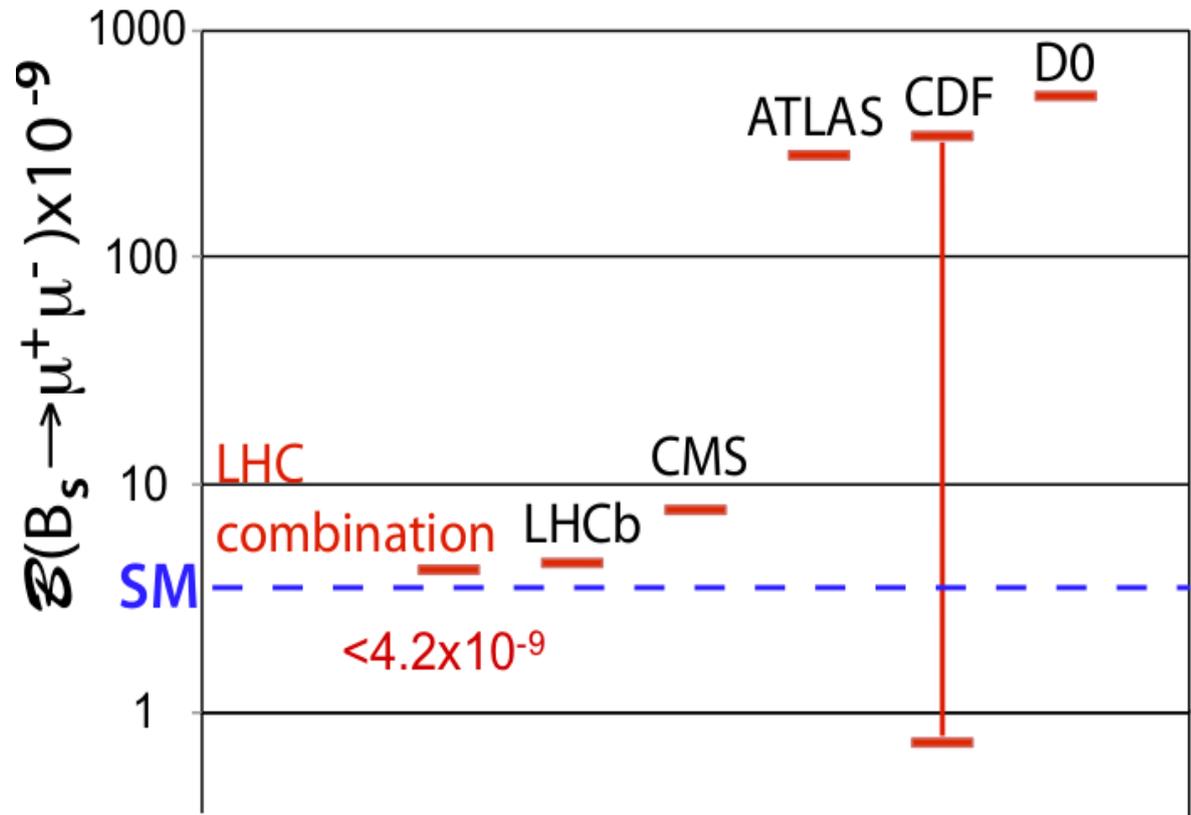
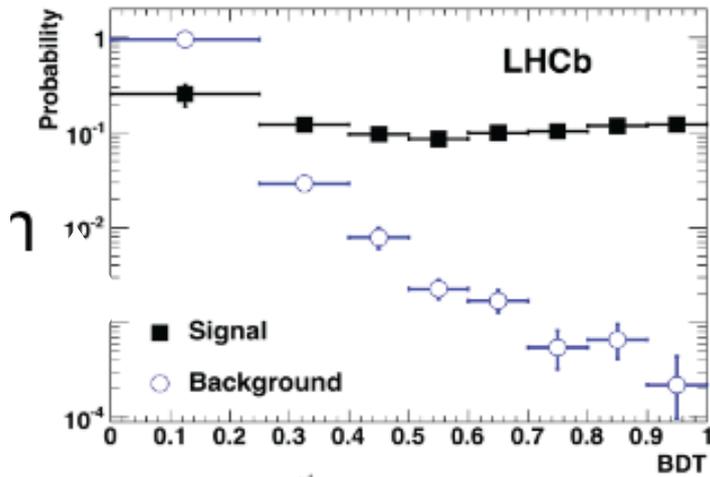
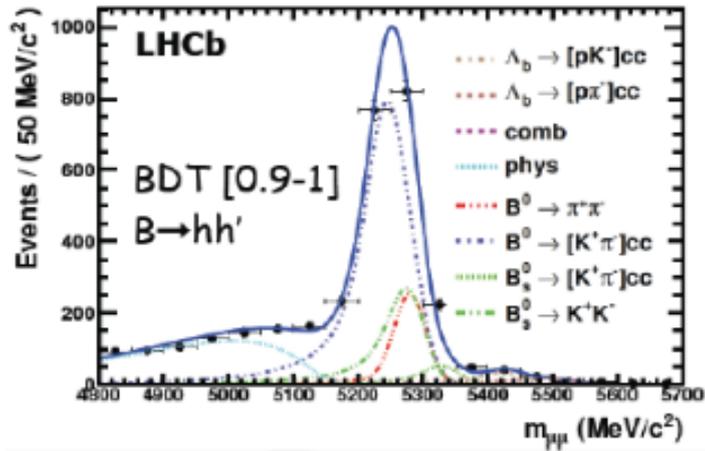
# Désintégrations rares

- $B_s \rightarrow \mu\mu$



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•  $B_s \rightarrow \mu\mu$

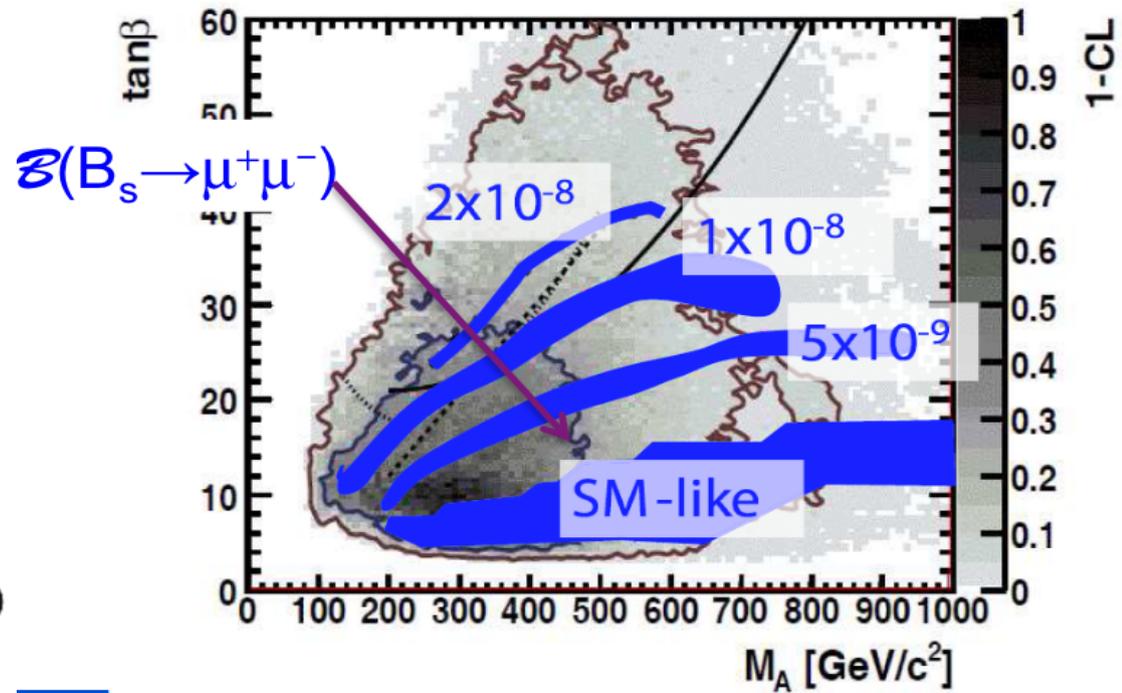
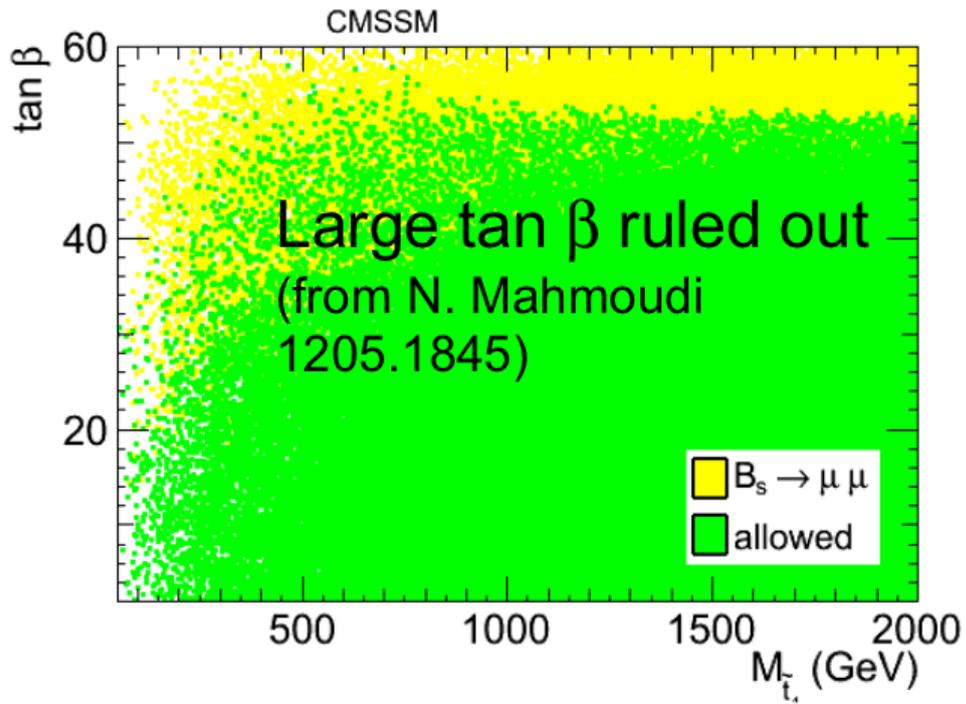


Limite :  $B < 4.2 \cdot 10^{-9}$

SM :  $B \sim 3.2 \cdot 10^{-9}$

# Désintégrations rares

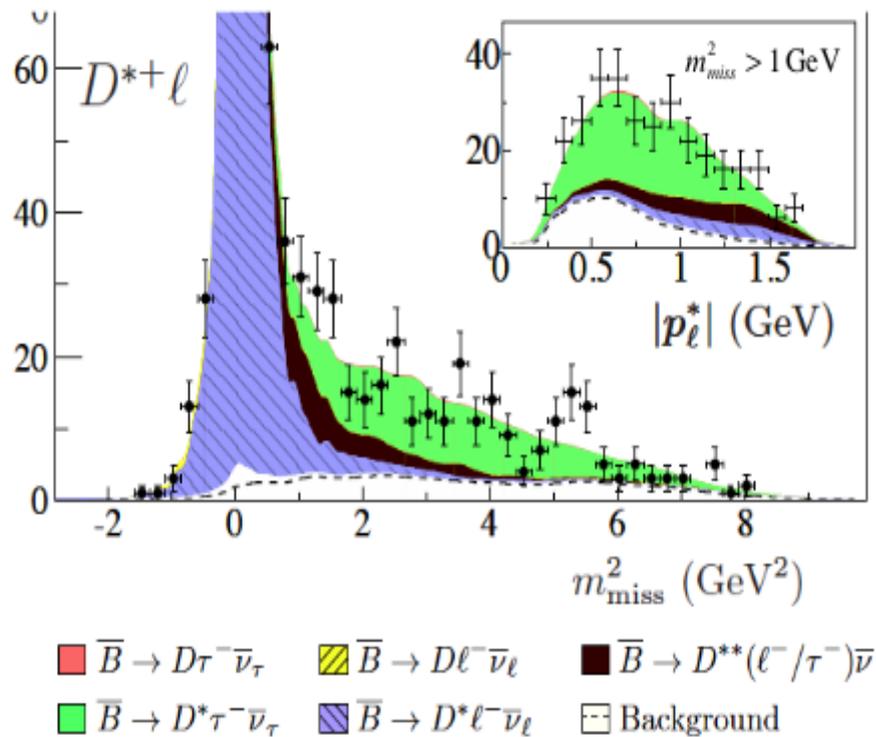
- $B_s \rightarrow \mu\mu$



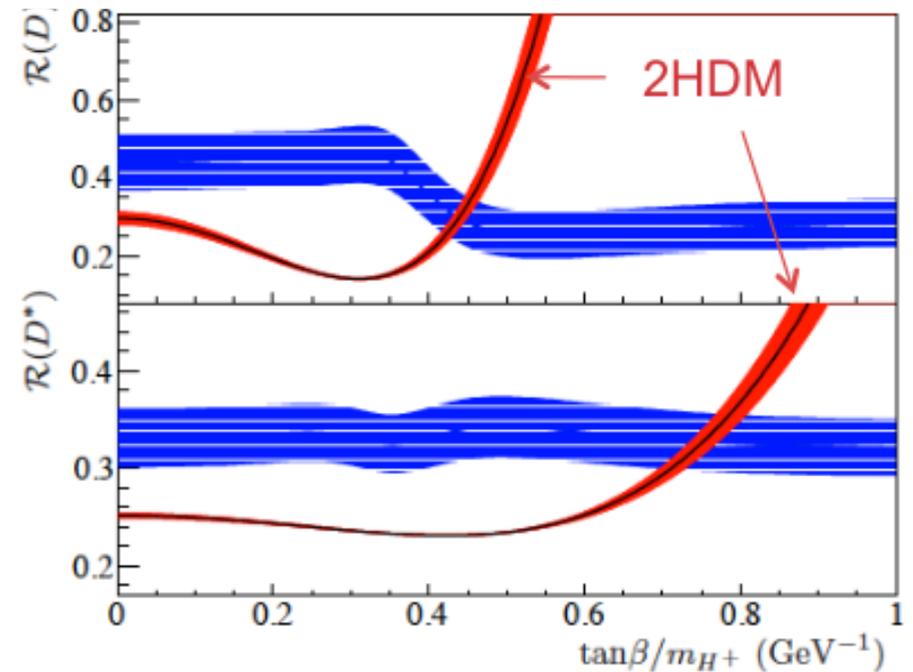
# Désintégrations rares

- $B \rightarrow D^{(*)} \tau \nu$

- ➔ Mesure :  $B(D\tau\nu) / B(D\ell\nu)$



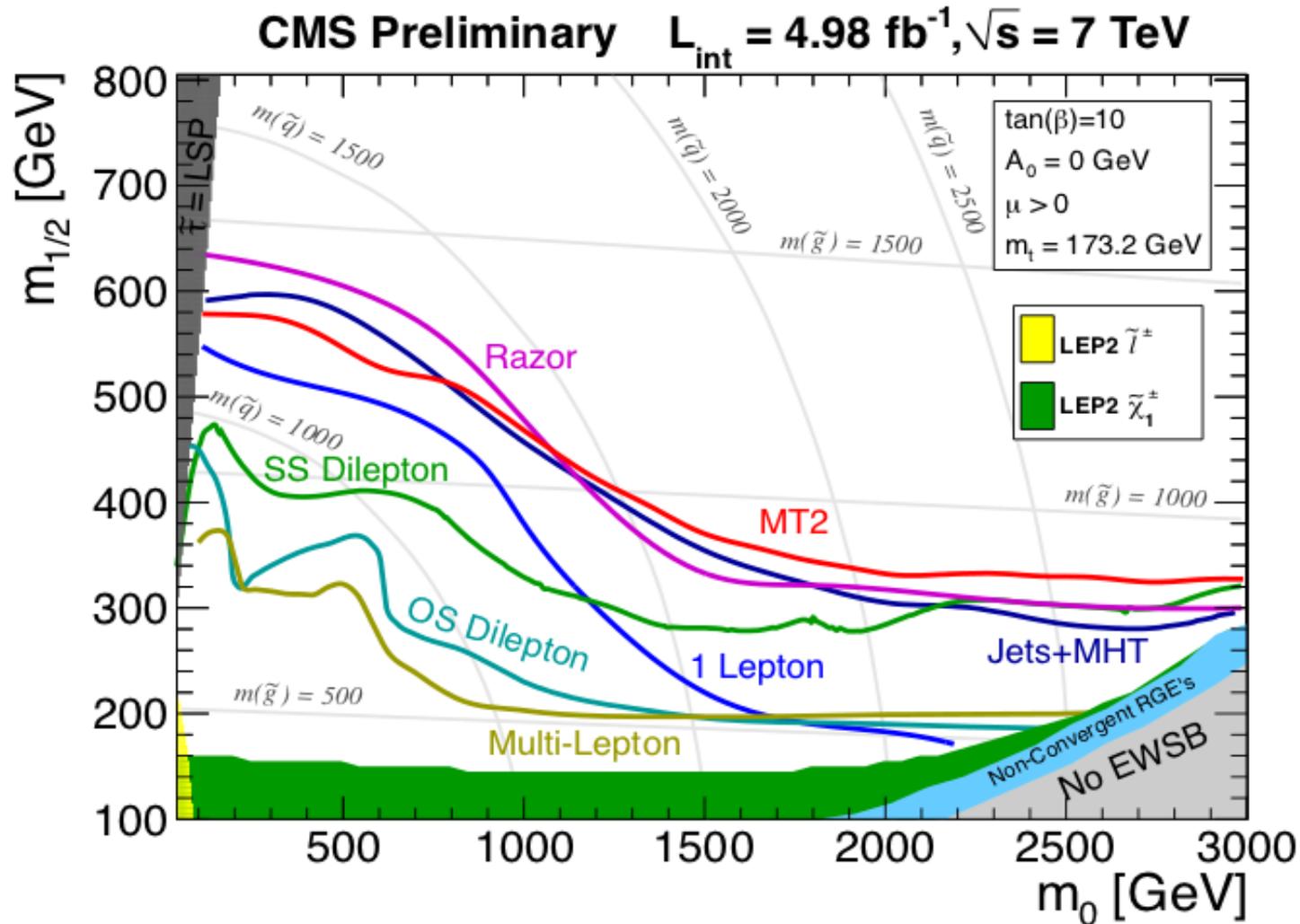
|       | SM Theory   | BaBar value       | Diff. |
|-------|-------------|-------------------|-------|
| R(D)  | 0.297±0.017 | 0.440±0.058±0.042 | +2.0σ |
| R(D*) | 0.252±0.003 | 0.332±0.024±0.018 | +2.7σ |





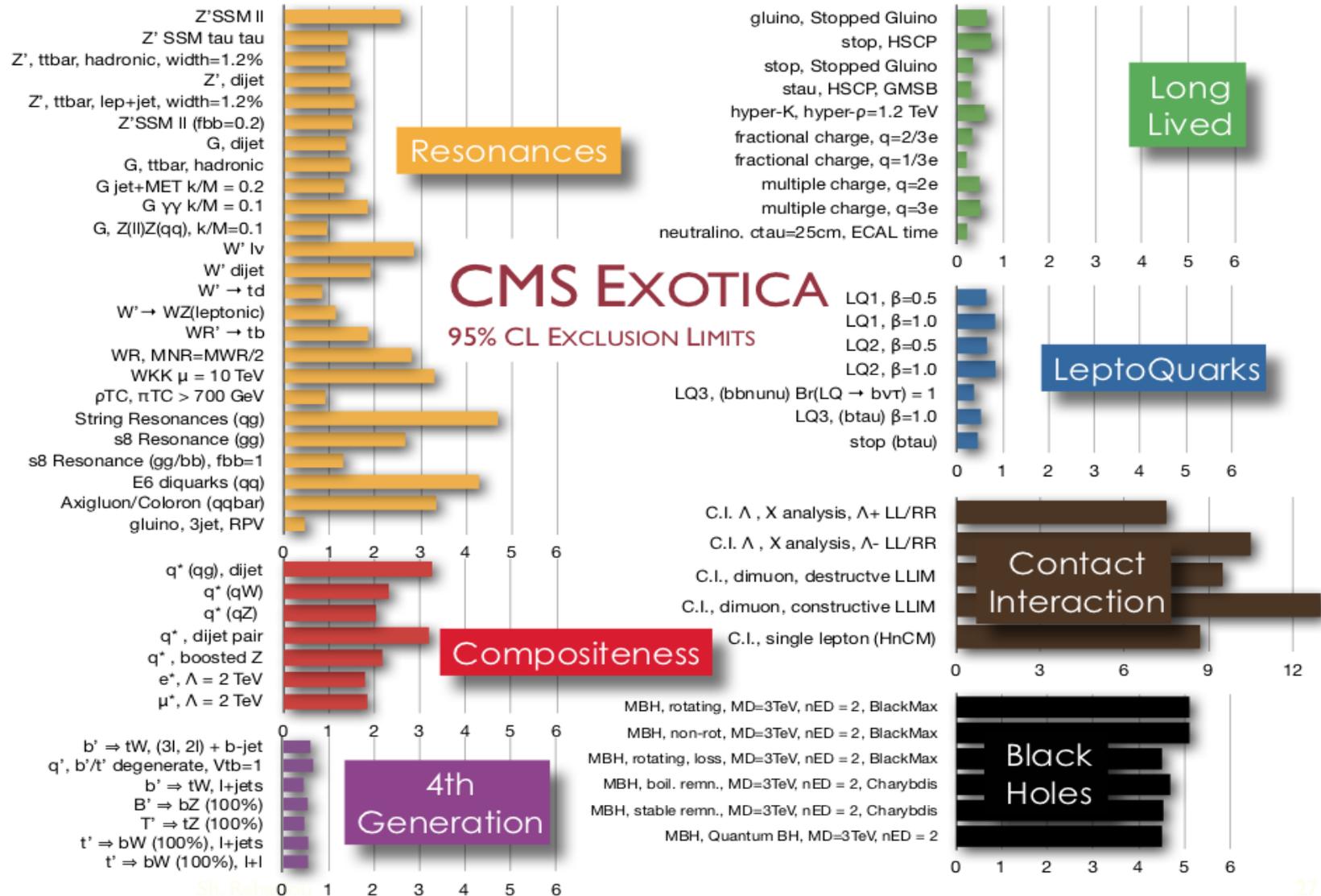
# Recherche directe de la supersymétrie

- Vue d'ensemble, CMSSM



# Au-delà de la supersymétrie

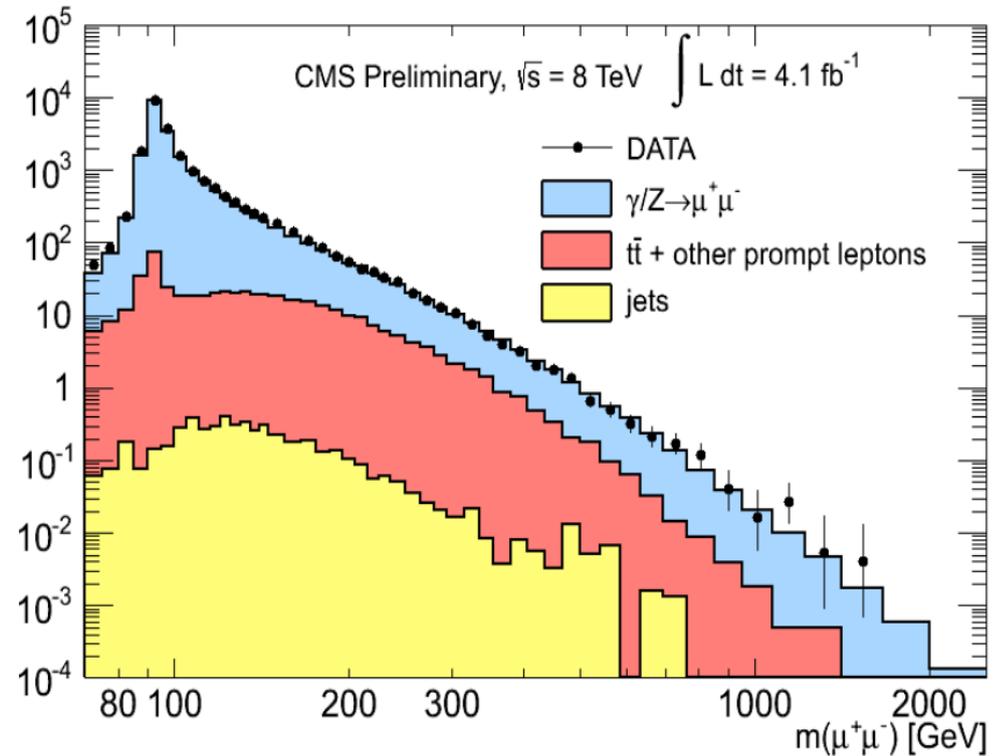
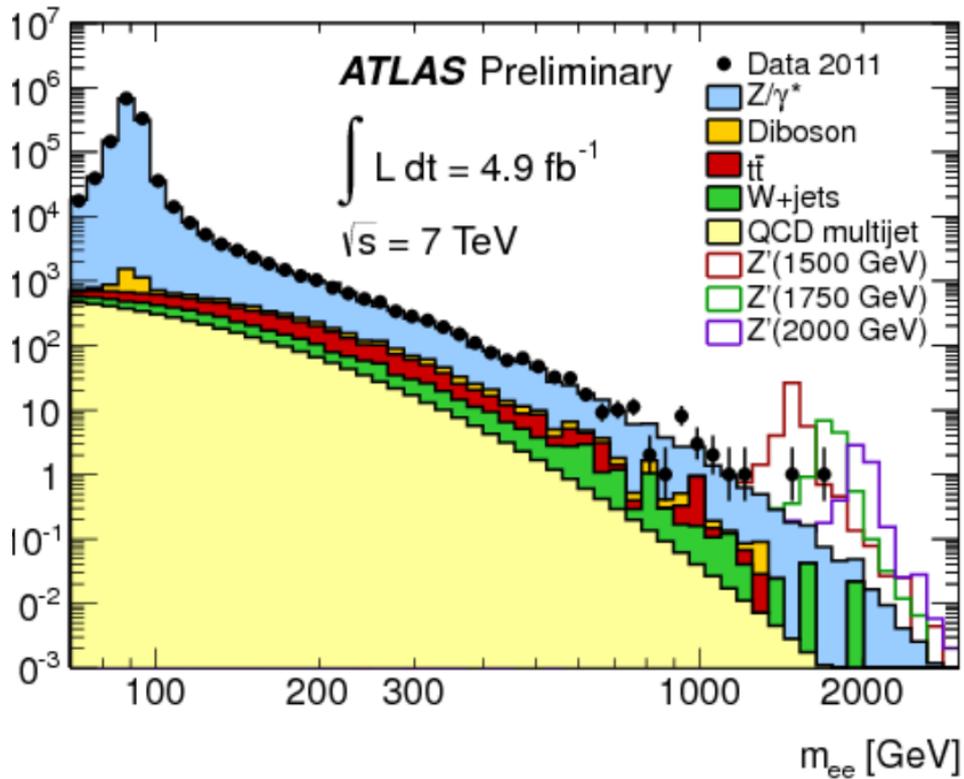
- Vue d'ensemble...



# Au-delà de la supersymétrie

- Z'

➔ Bon data/MC jusqu'au TeV, limites  $\sim 1$  TeV (Z'),  $\sim 3$  TeV (W')



# Au-delà de la supersymétrie

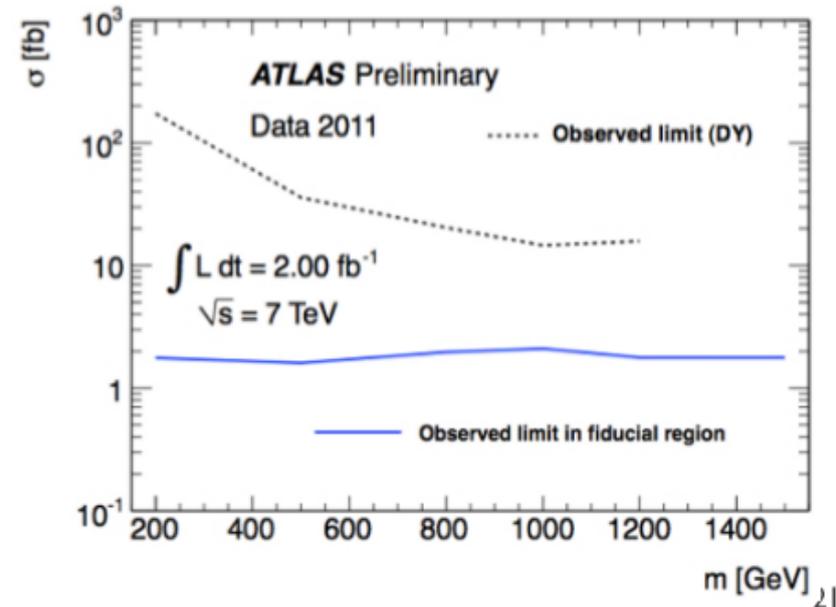
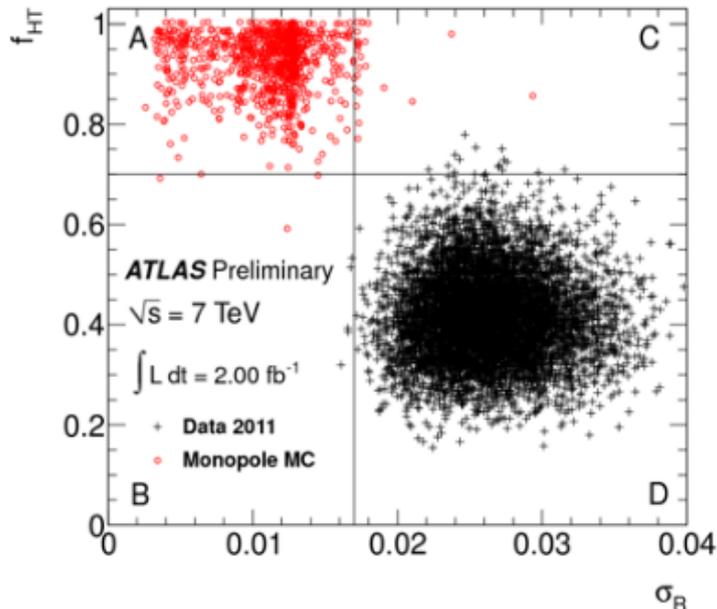
- Monopoles magnétiques / signal fortement ionisant dans le TRT d'ATLAS

- Magnetic charge  $g$  yields strong coupling  $\alpha_m$  and very high ionisation

$$\frac{ge}{\hbar c} = \frac{1}{2} \Rightarrow \frac{g}{e} = \frac{1}{2\alpha_e} \approx 68.5 \qquad \alpha_m = \frac{(g\beta)^2}{\hbar c} = \frac{1}{4\alpha_e}\beta^2$$

- Look for high ionisation in Transition Radiation Tracker and high hit fraction ( $f_{HT}$ ) and also deposition in the Liquid Argon Electromagnetic Calorimeter
- Pair-produced (Drell-Yan) production

*Cross Section limits set for  $m(M) = 0.2-1.2$  TeV*

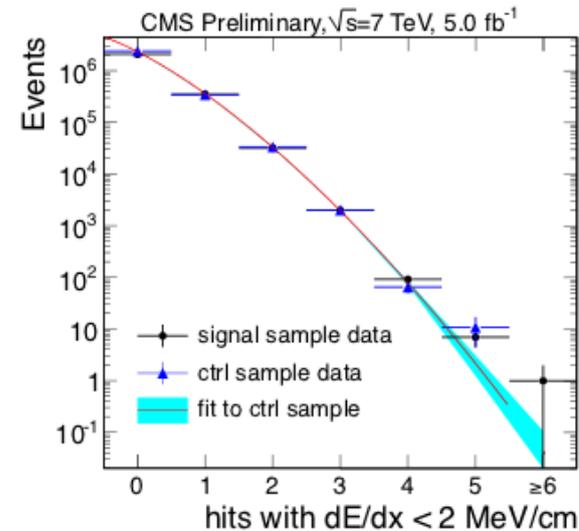
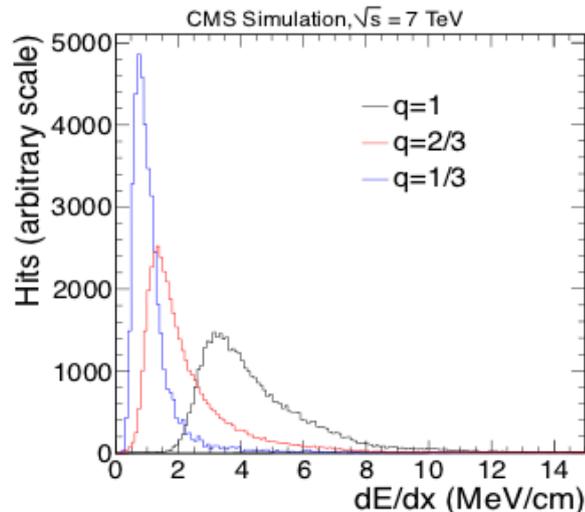
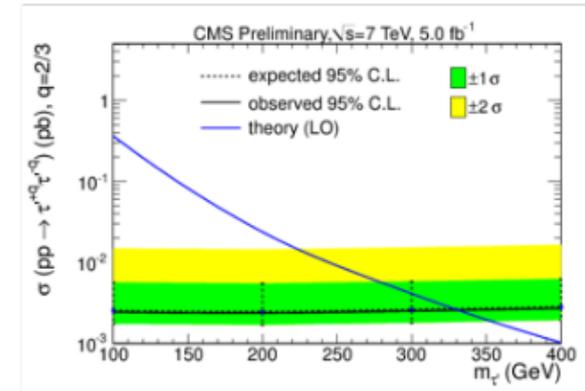


# Au-delà de la supersymétrie

- Charges fractionnaires /  $dE/dX$  dans le silicium de CMS

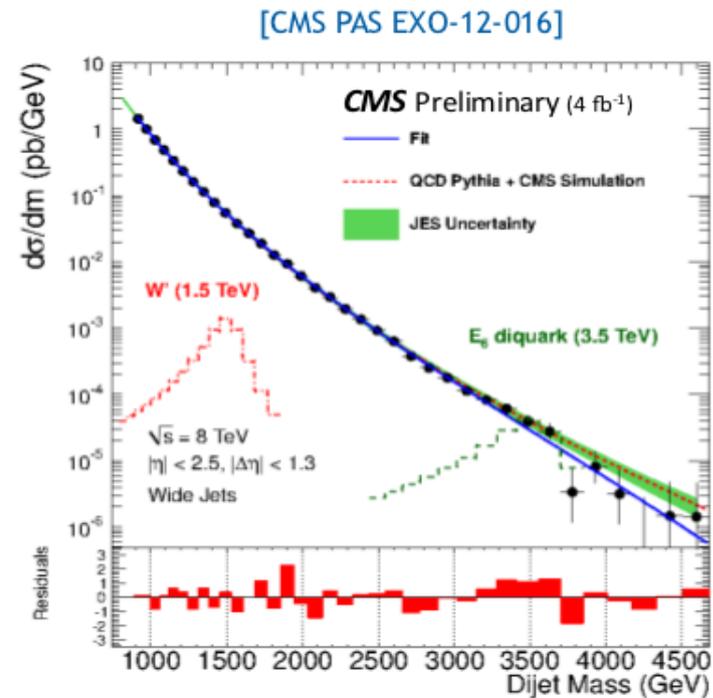
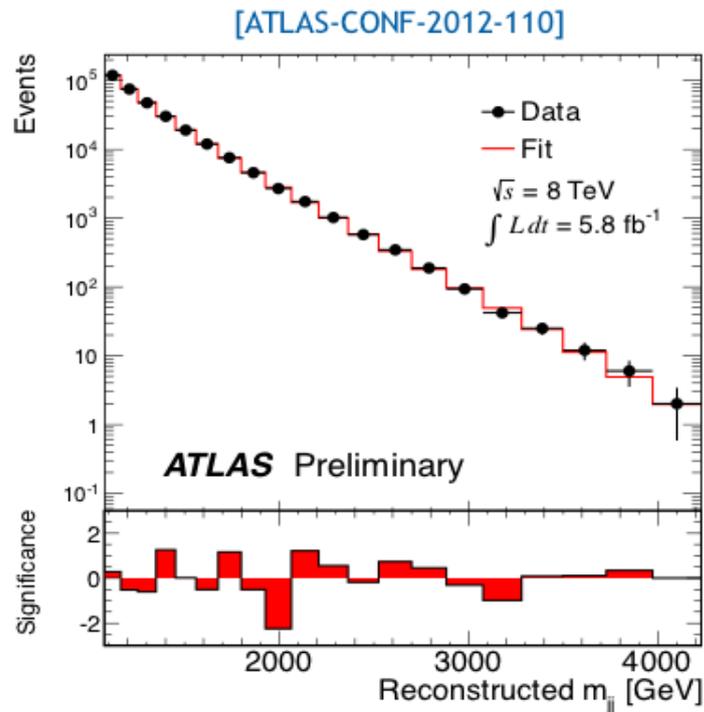
- Search for long-lived particles with fractional charge
- Backgrounds
  - Cosmics: estimate from  $d_{xy}$  sidebands
  - Collisions: using  $Z \rightarrow \mu\mu$  data, fit  $N_{\text{hits}}$  with low  $dE/dx$
- Assume lepton-like spin=1/2 particle masses

*Exclude:  $Q = e/3: m > 210$   
 $Q = 2e/3: m > 330$*



# Au-delà de la supersymétrie

- Dijets

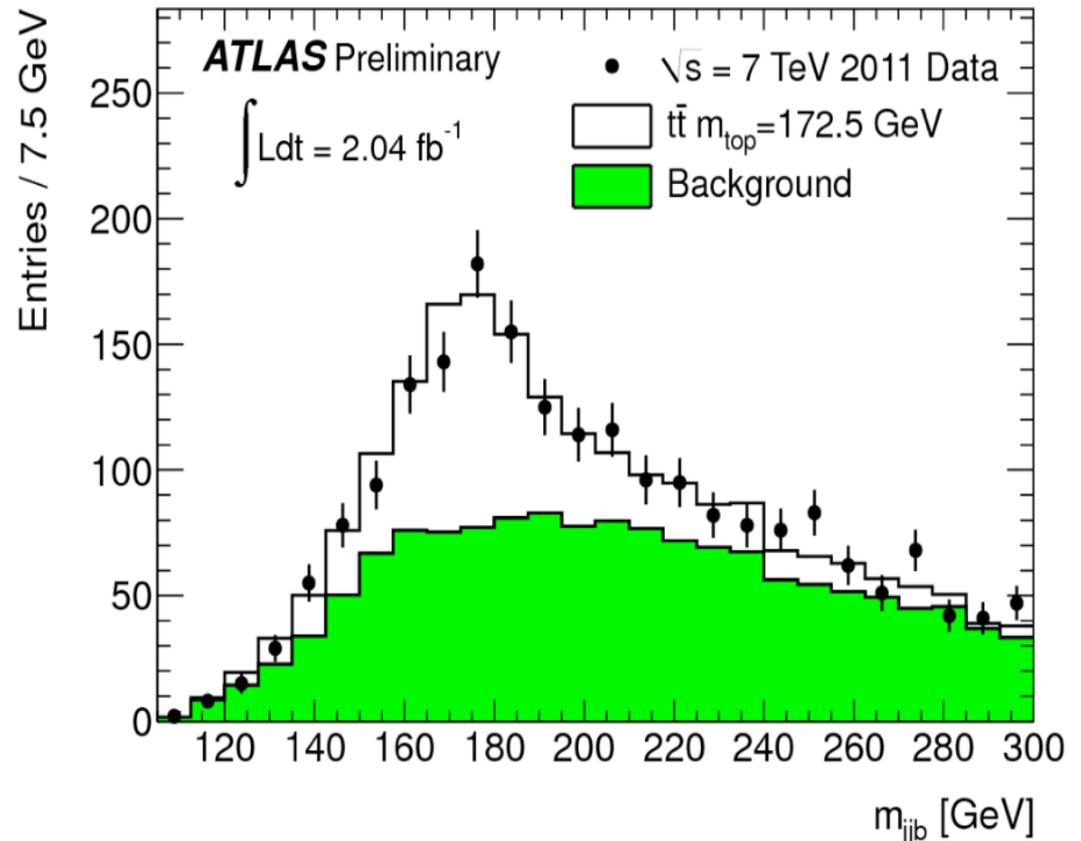
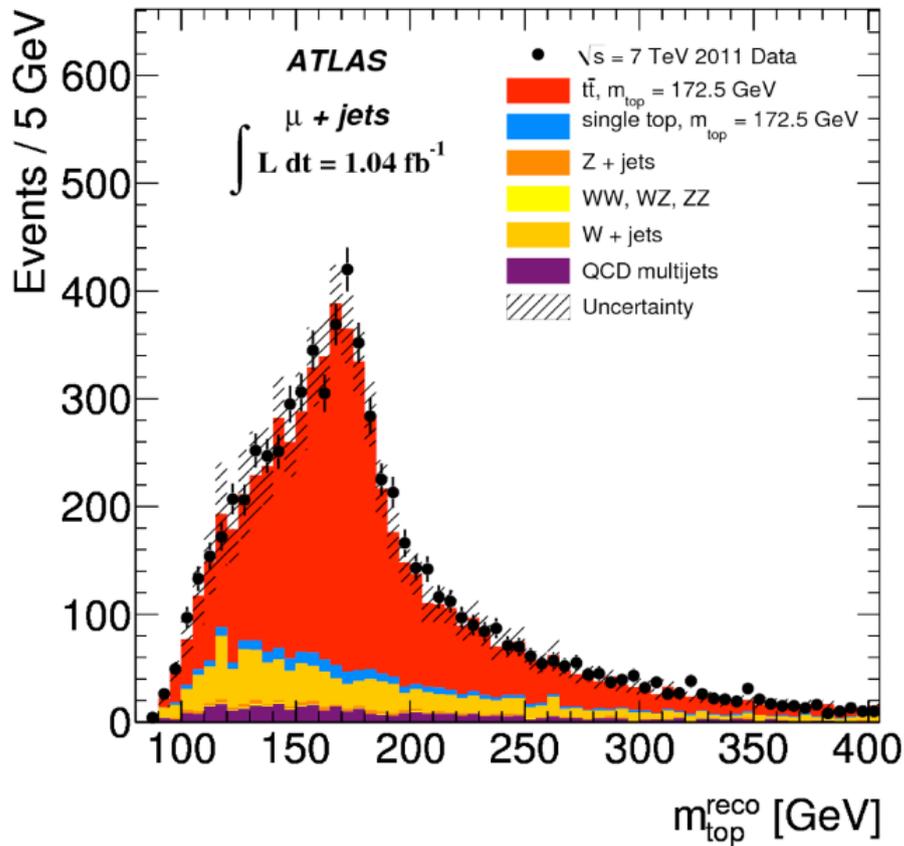


- Search for dijet resonance in smoothly falling mass spectrum
  - leading jet mass  $m_{jj} > 0.9\text{-}1 \text{ TeV}$  from trigger and other constraints
  - Background estimated from smooth functional fit

$$\frac{d\sigma}{dm_{jj}} = \frac{P_0(1-x)^{P_1}}{x^{P_2+P_3 \ln(x)}}$$

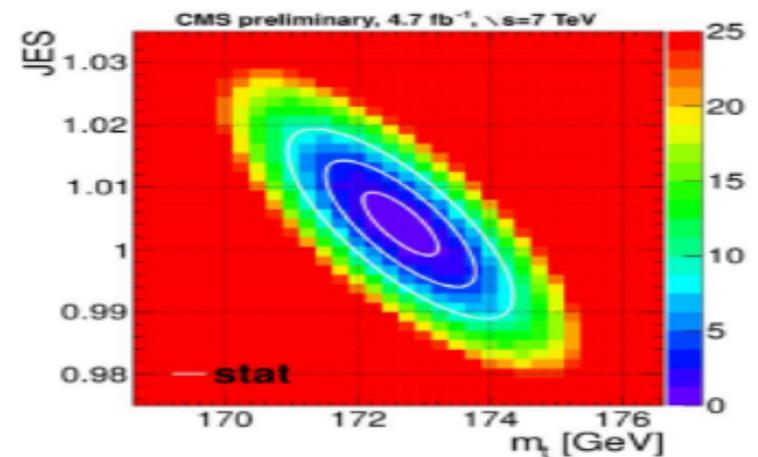
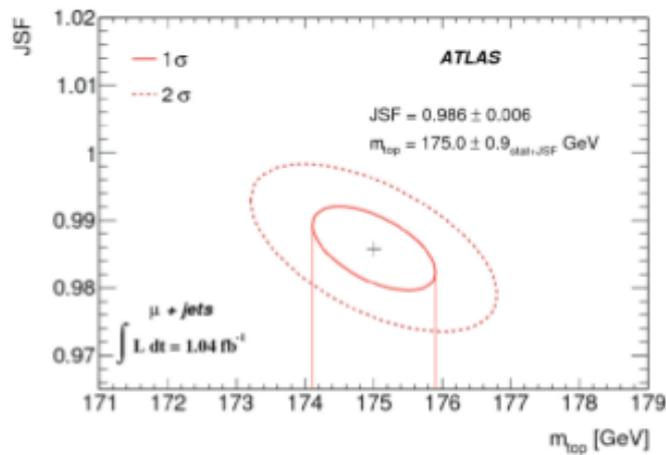
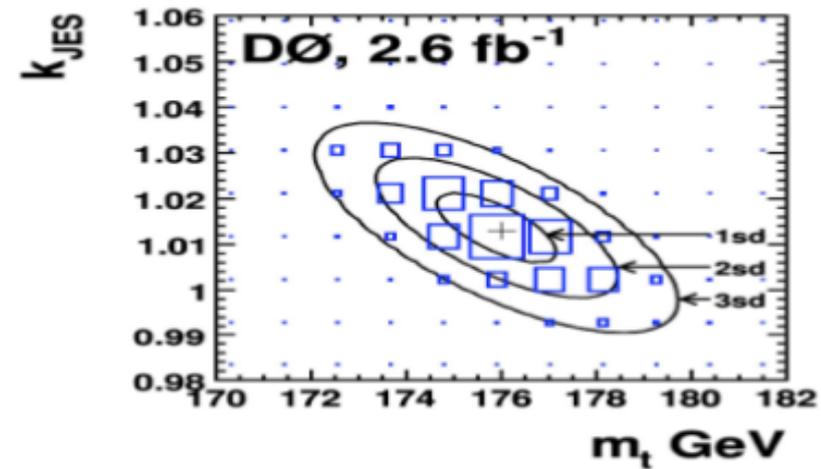
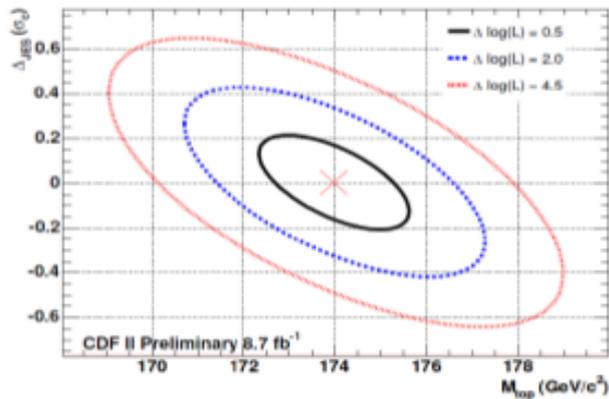
# Quark top

- Mesure de masse



# Quark top

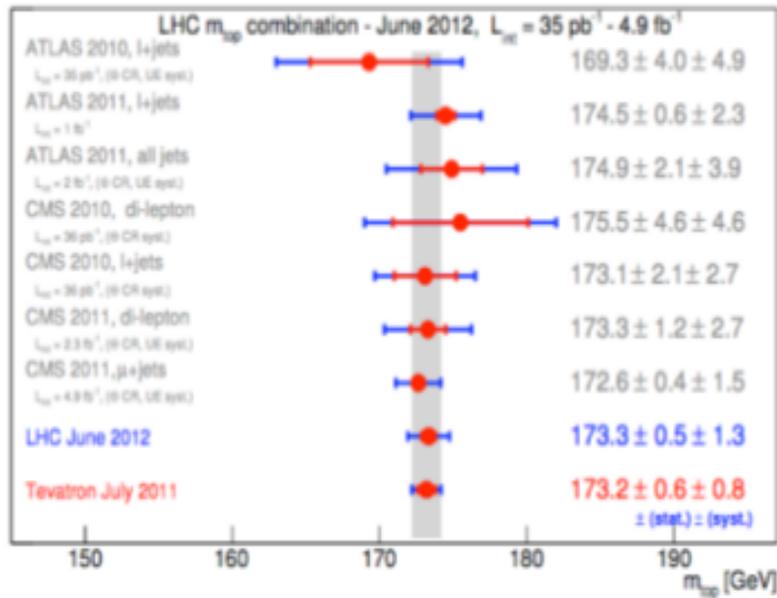
- Mesure de masse, et contrainte de l'échelle d'énergie des jets "in situ"



# Quark top

- Mesure de masse
  - ➔ Combinaisons Tevatron, et LHC

## – LHC combination and perspectives



TeV:  $m_t^{\text{comb}} = 173.18 \pm 0.56 \text{ (stat)} \pm 0.75 \text{ (syst)} \text{ GeV}$   
 $= 173.18 \pm 0.94 \text{ GeV}$

LHC:  $m_{top} = 173.3 \pm 0.5 \text{ (stat)} \pm 1.3 \text{ (syst)} \text{ GeV}$   
 $= 173.3 \pm 1.4 \text{ GeV}$

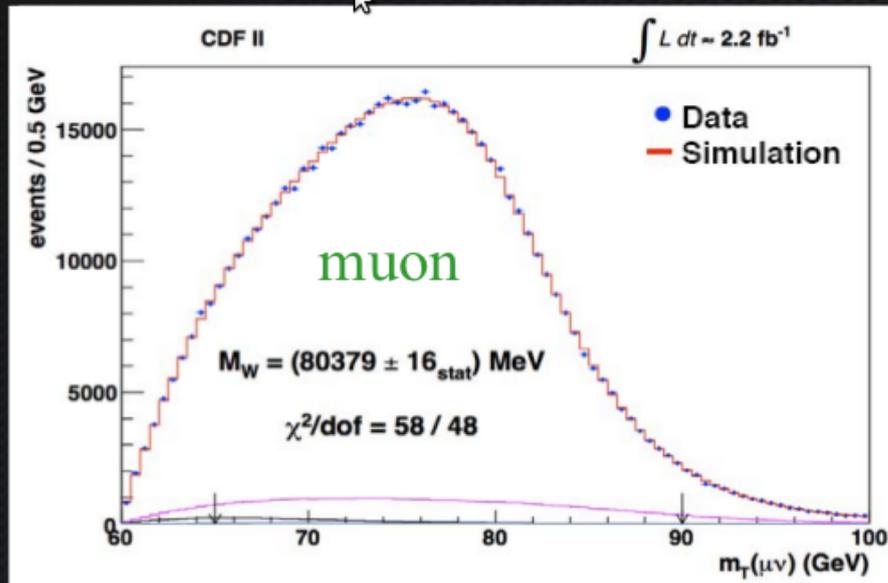
ATLAS-CONF-2012-095

CMS PAS TOP-12-001

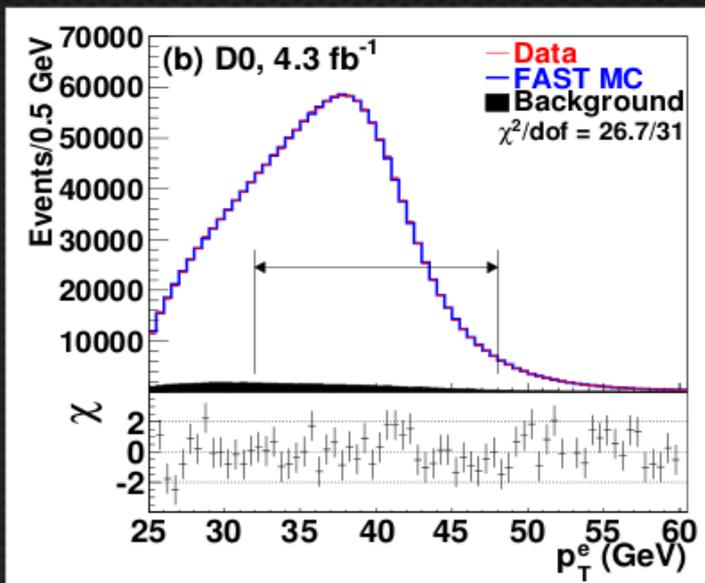
# Le W

- $M_W$  a D0, CDF

PRL 108, 151803 (2012)



Phys. Rev. Lett. 108, 151804 (2011)



**Fits transverse mass, lepton  $p_T$  and neutrino  $p_T$**

**Uses both e and  $\mu$**

**$2.2 \text{ fb}^{-1}$**

**1.1 M W events**

**$\Delta m_W(\text{sys}) = 18 \text{ MeV (e)}$**

**$\Delta m_W(\text{sys}) = 16 \text{ MeV } (\mu)$**

**Uses only e**

**$4 + 1 \text{ fb}^{-1}$**

**1.7 M W events**

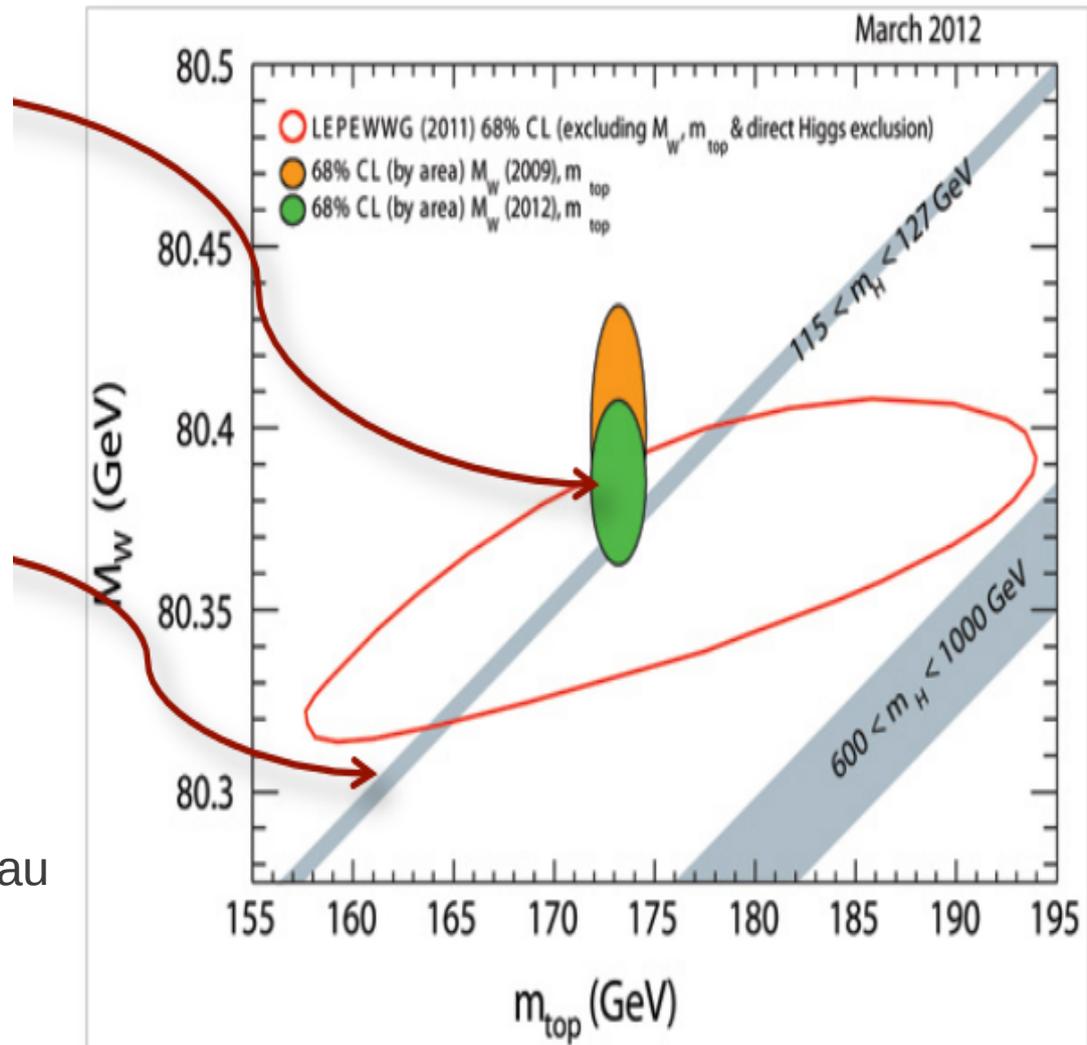
**$\Delta m_W(\text{sys}) = 22 \text{ MeV (e)}$**

# Ajustement électrofaible

Amélioration de  $M_W$   
au Tevatron

Zone permise avant la  
découverte

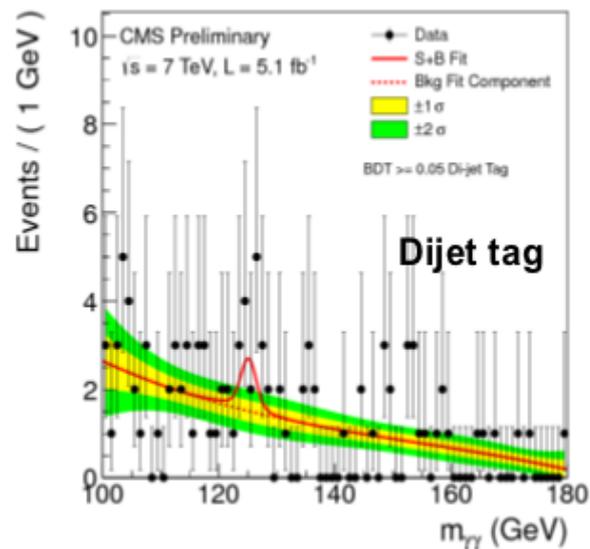
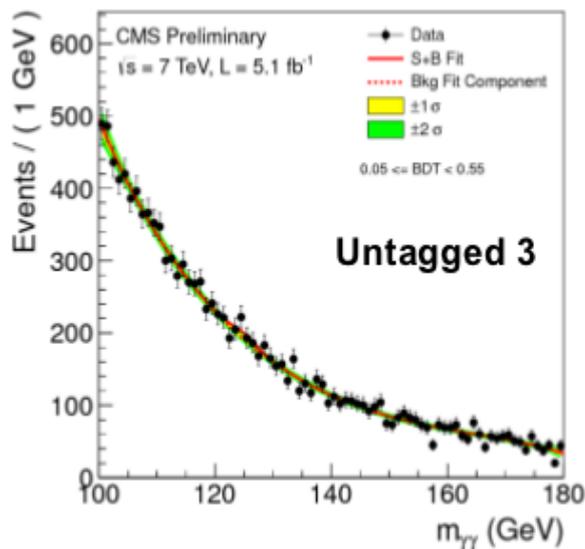
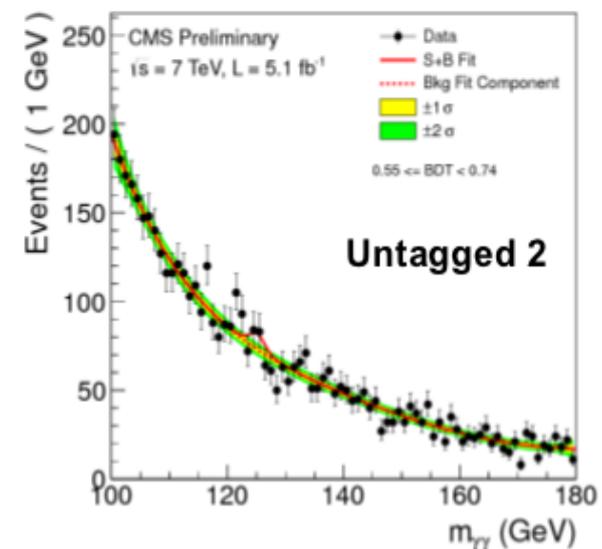
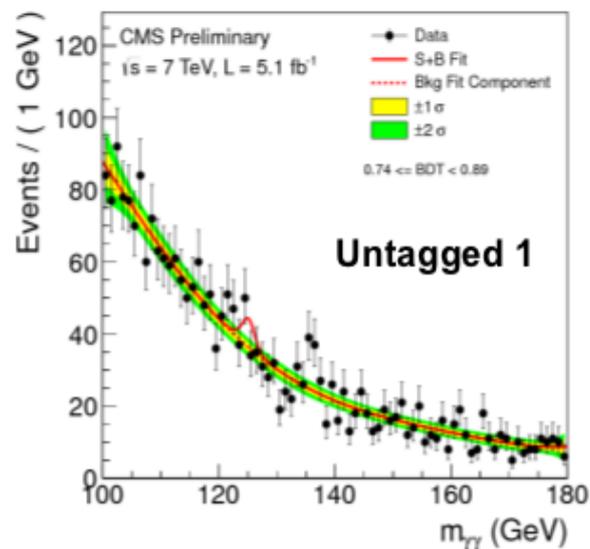
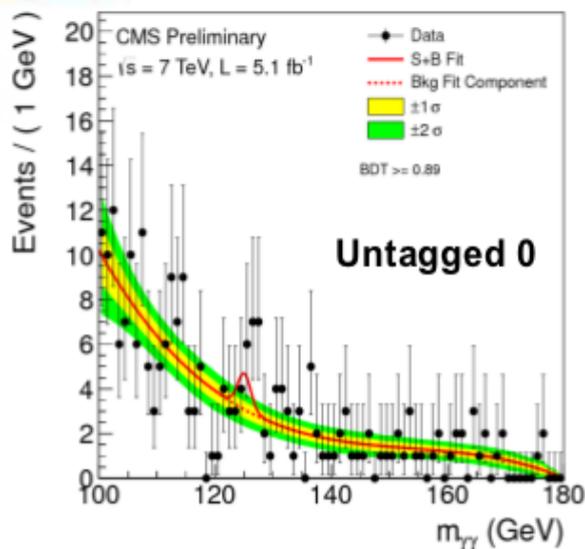
L'incertitude sur le  $W$  domine.  
Pour que  $m_{TOP}$  devienne de nouveau  
discriminant, il faut  $\delta M_W \sim 5 \text{ MeV}$



# Résumé

- Si la nouvelle particule est le boson de Higgs, sa masse observée est telle que le domaine de validité “technique” du MS est  $\sim$ maximal
- Les recherches directes ne montrent toujours aucun signe nouvelle physique
- Les désintégrations rares, et les mesures de précision ( $m_W$ ,  $m_{top}$ ) n'indiquent pas, pour l'instant, de contribution venant de l'au-delà (du MS)
- Mais:
  - ➔ Encore de la marge pour  $M_W$ ,  $m_{TOP}$
  - ➔ A suivre :  $B_s \rightarrow \mu\mu$ ,  $B \rightarrow D^{(*)} \tau \nu$
  - ➔ Les propriétés de la nouvelle particule restent entièrement à déterminer
    - Arrivée plus tôt que prévu – couplage fort?
    - couplage aux fermions!

# back-up



- Background model is entirely from data.
- Fit mass distribution in each category, polynomials of 3<sup>rd</sup> to 5<sup>th</sup> degree
  - keep bias < 20% of fit error.
  - *causes some loss of performance due to number of parameters in fit function.*

