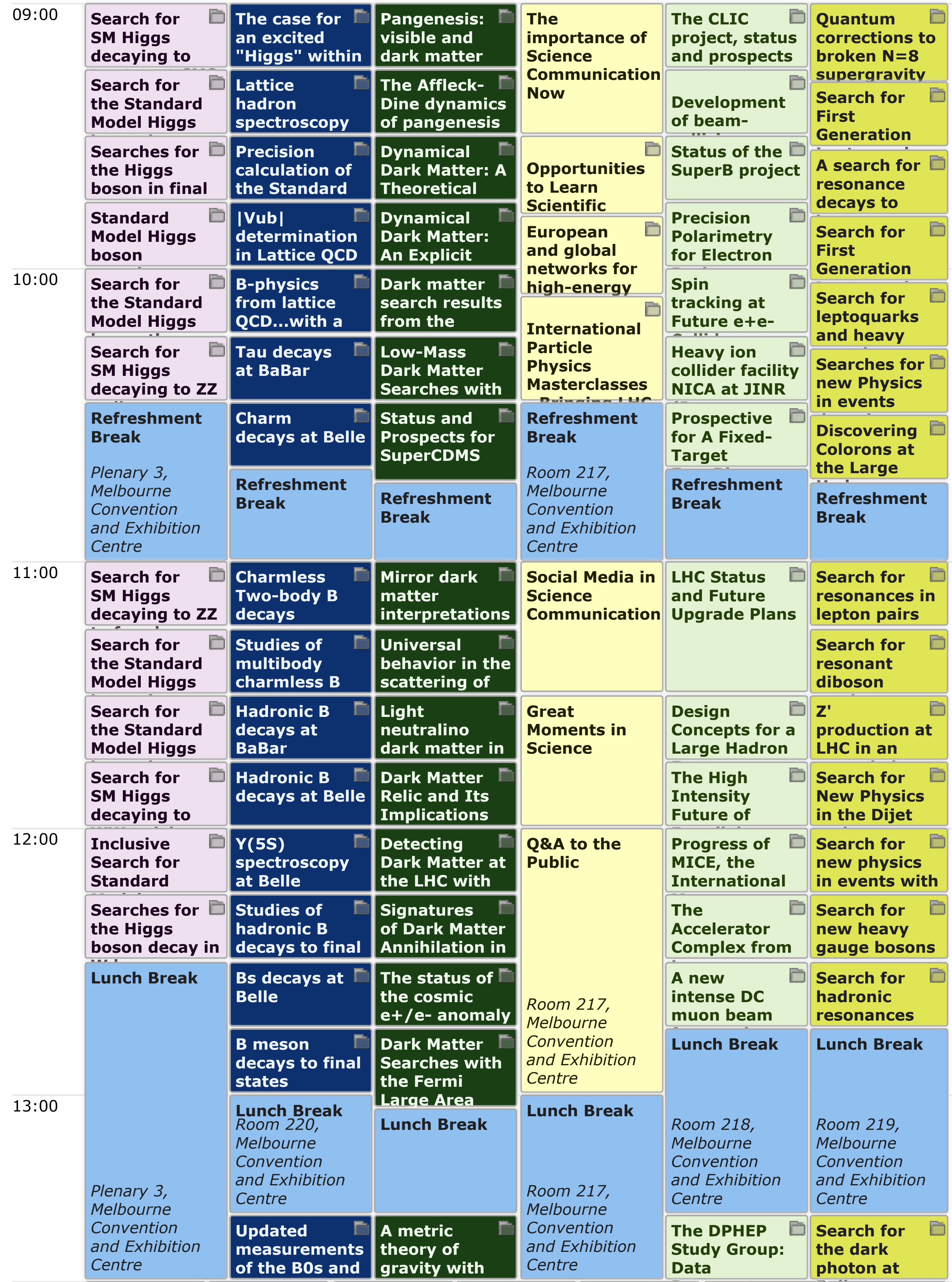
ICHEP 2012

International Conference on High Energy Physics
4-11 Juillet 2012, Melbourne, Australie

- 1 semaine, à Melbourne
- Plus de 1000 participants littéralement du monde entier
- 3 jours de sessions parallèles (15 à 20 minutes sur un sujet spécifique) et 3 jours de sessions plénières (exposés plus longs sur un domaine)
- En physique des particules, conférences d'hiver (Moriond) et d'été (ICHEP, Lepton-Photon, EPS-HEP)
- Autant pour les présentations, calibrées, que pour les discussions, informelles, aux pauses
- Autres occasions de rencontres: conférences, workshops spécialisés, séminaires....

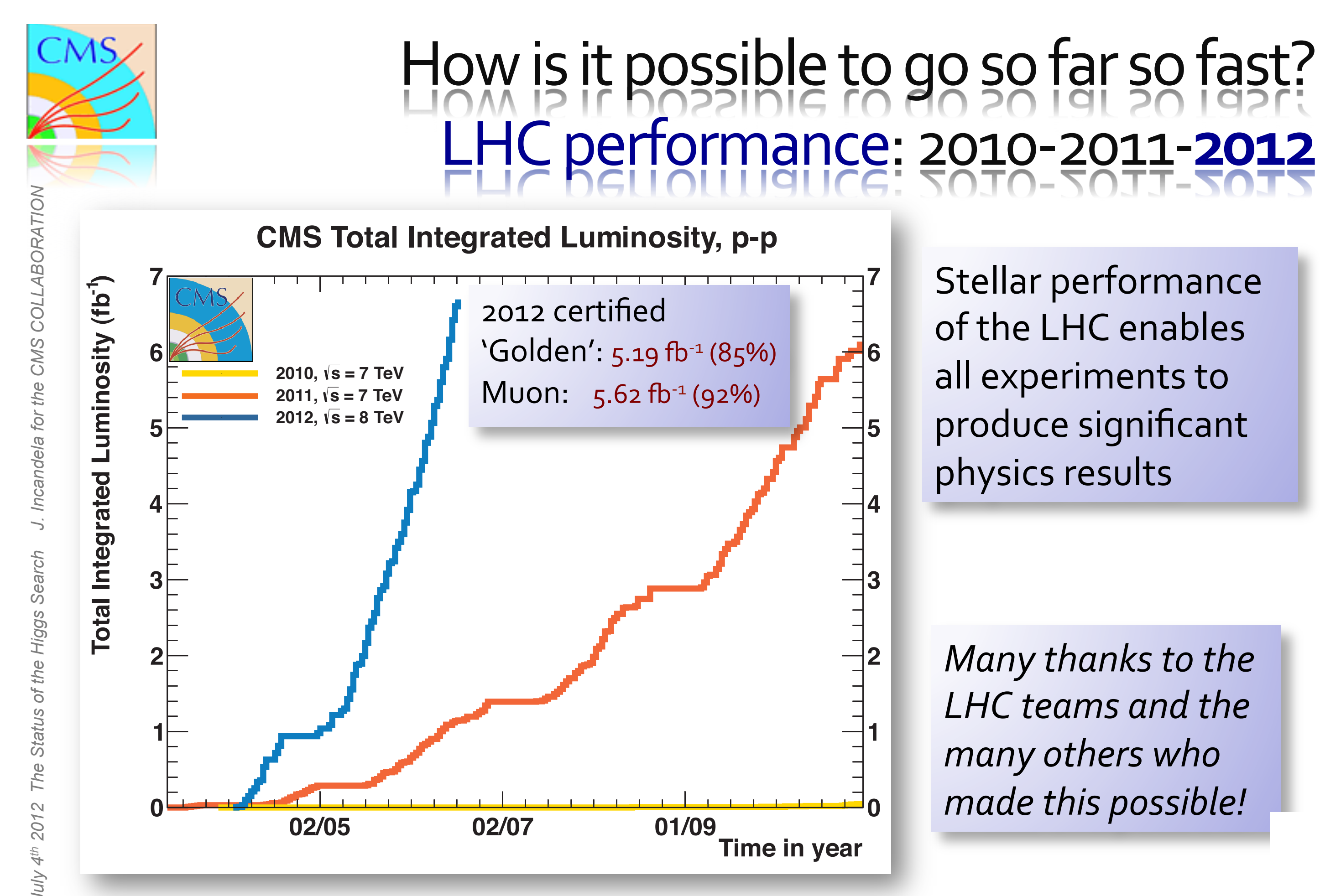


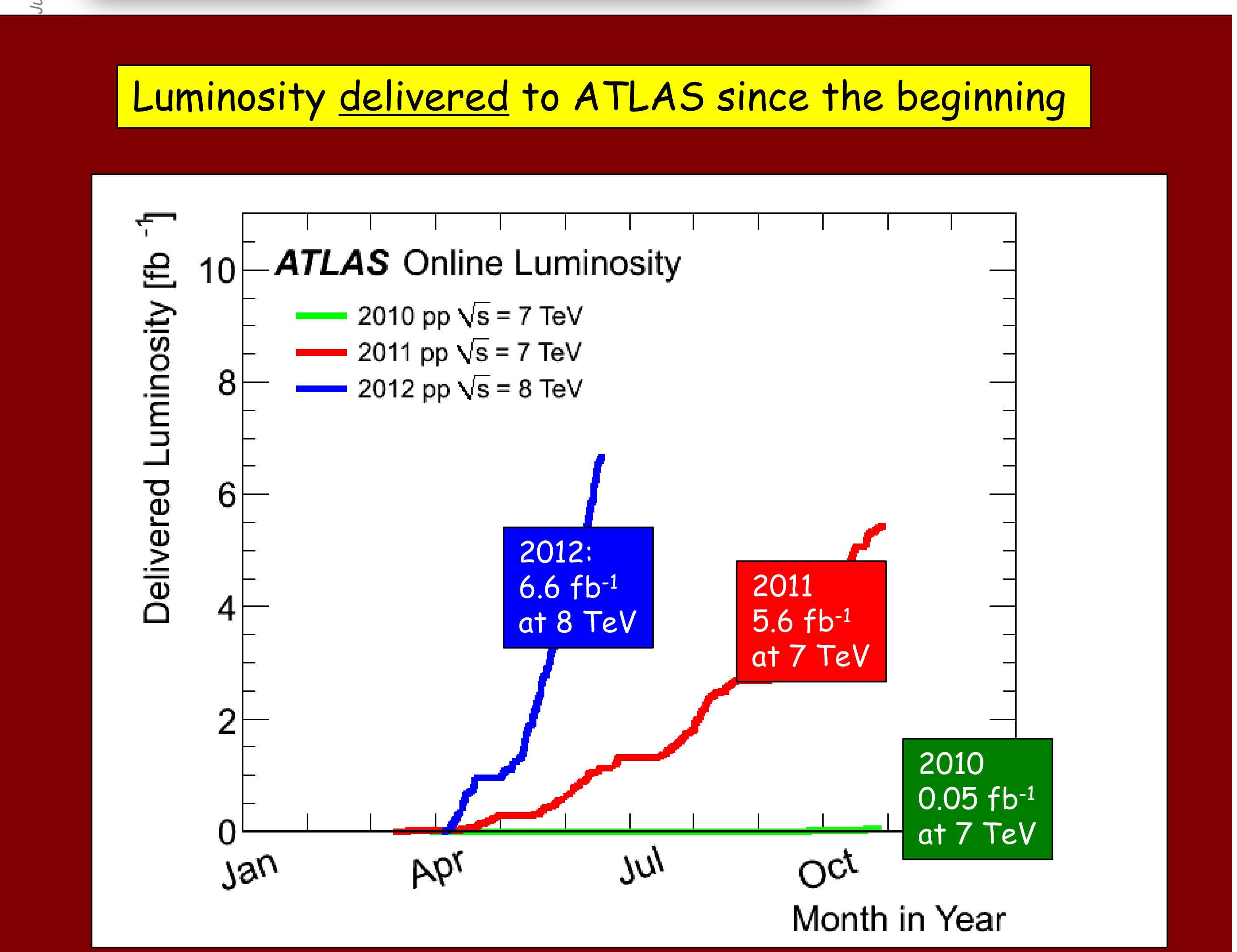
42 ?

125 !

La plus grande nouvelle d'ICHEP...
n'a pas été annoncée à Melbourne, mais au CERN !

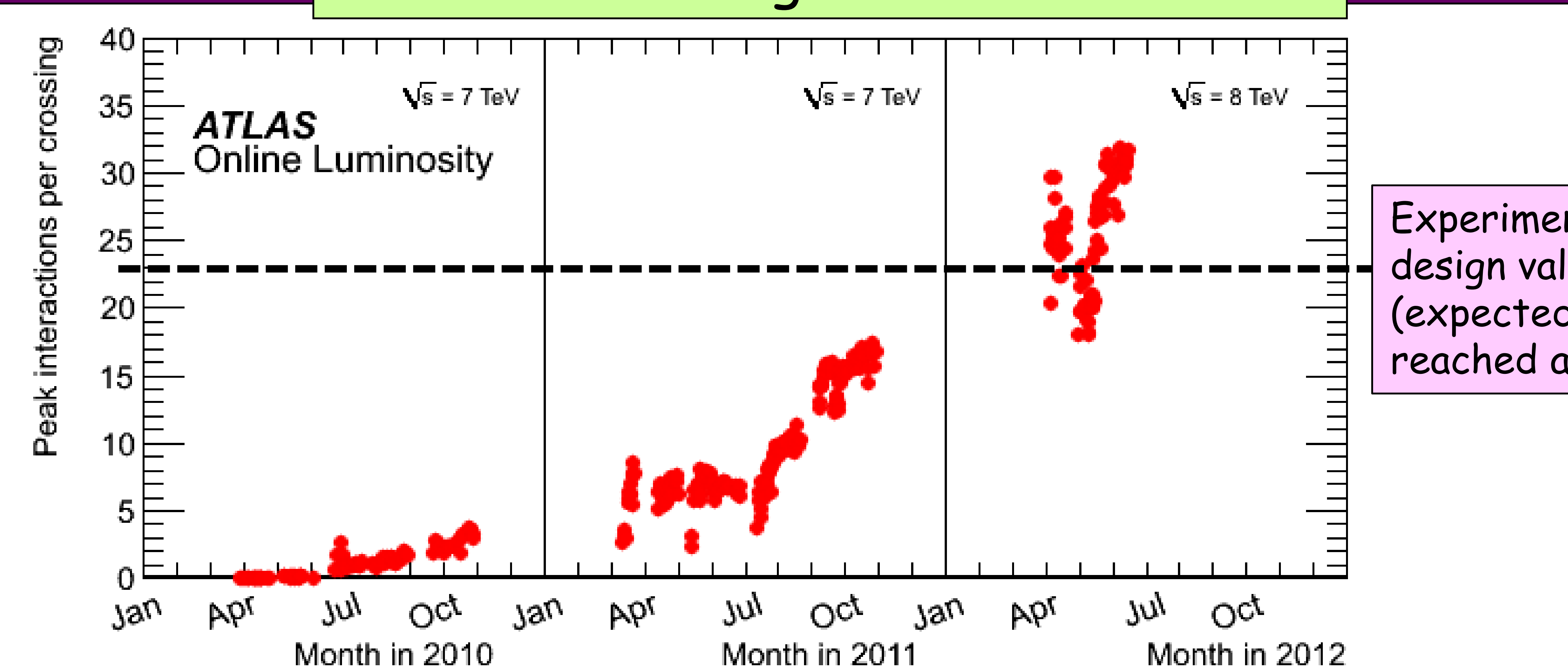
... en particulier pour Peter Higgs, mais aussi Robert Brout et Francois Englert, et Gerald Guralnik, Carl R. Hagen et Tom Kibble.



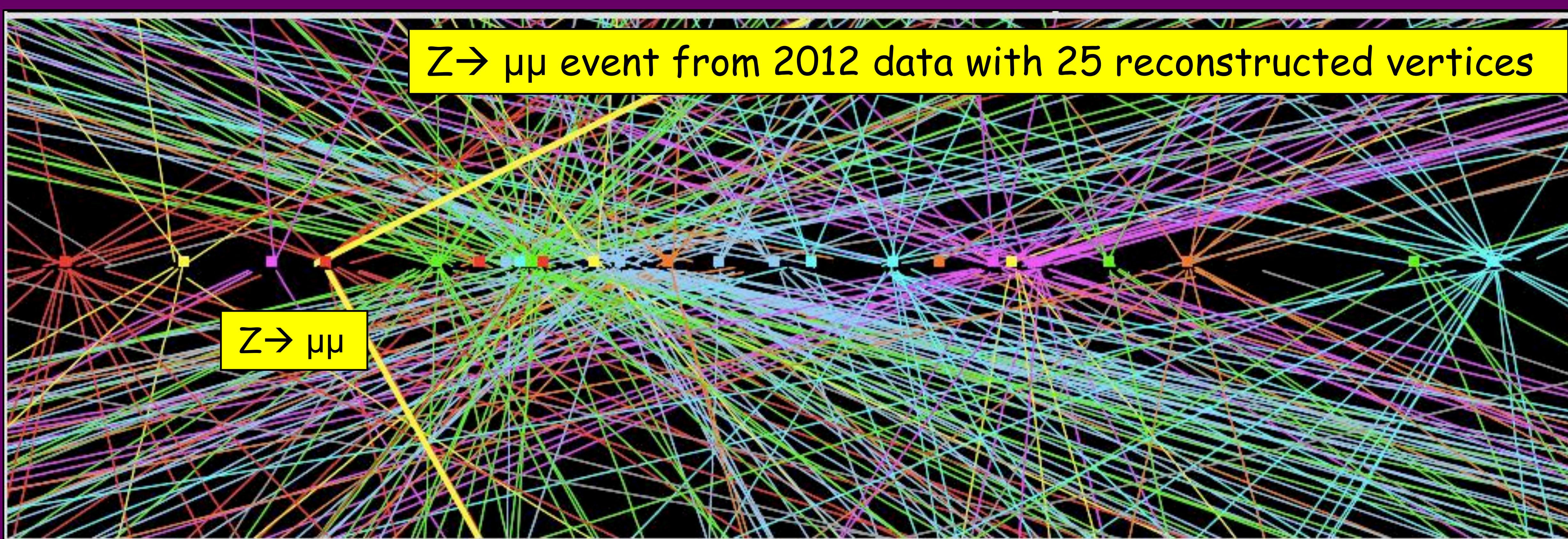


- Résultats très attendus… et un certain nombre de rumeurs de couloirs (ou de blogs !)
- Runs de 7 à 8 TeV, avec une augmentation très importante très rapide de la luminosité.
- Beaucoup plus de statistique, permettant aussi d'augmenter le signal et de mieux comprendre les bruits de fond.
- Avec la part du diable: le pile-up !

The BIG challenge in 2012: PILE-UP

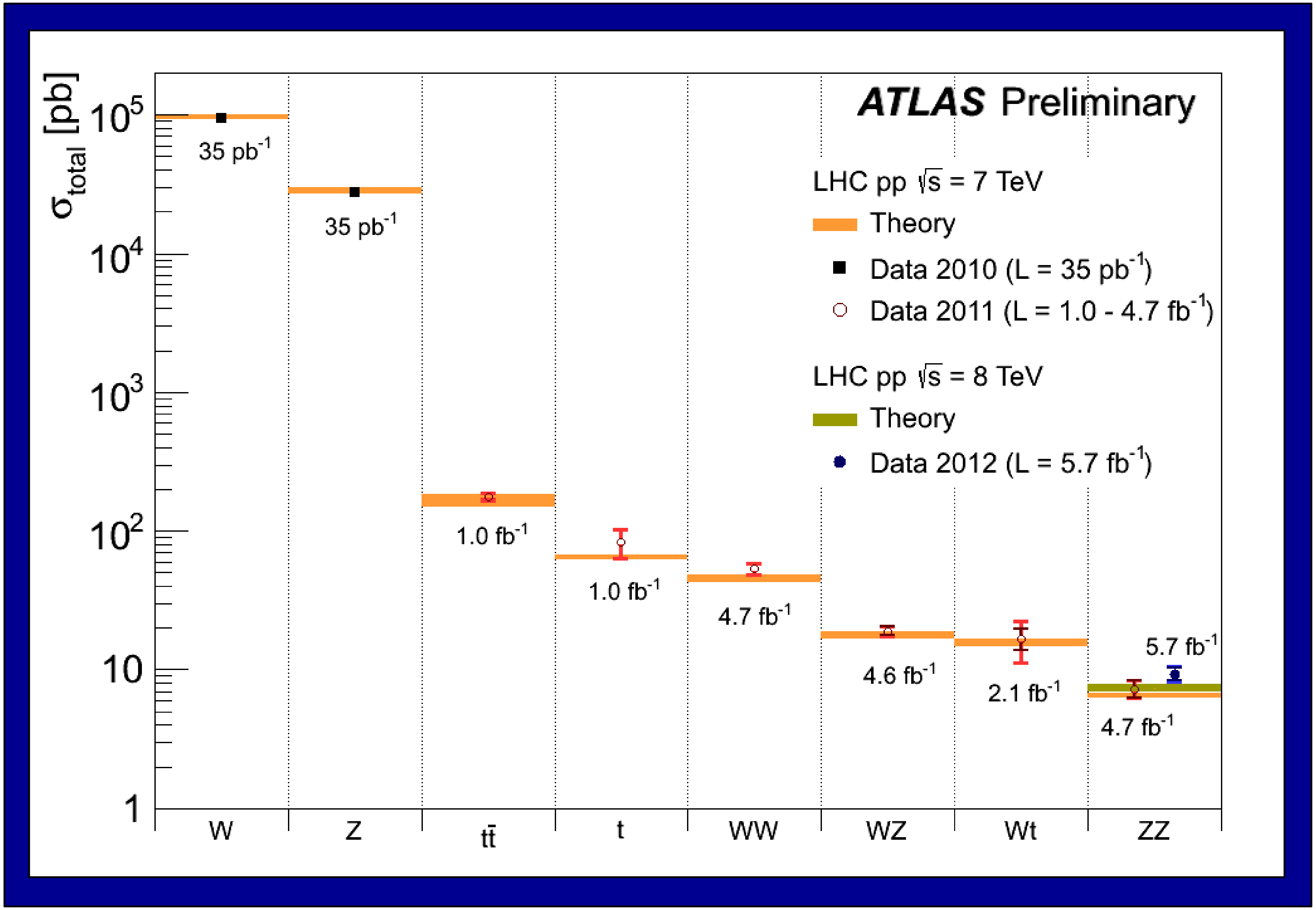


Experiment's design value (expected to be reached at $L=10^{34}$!)



Z→ μμ event from 2012 data with 25 reconstructed vertices

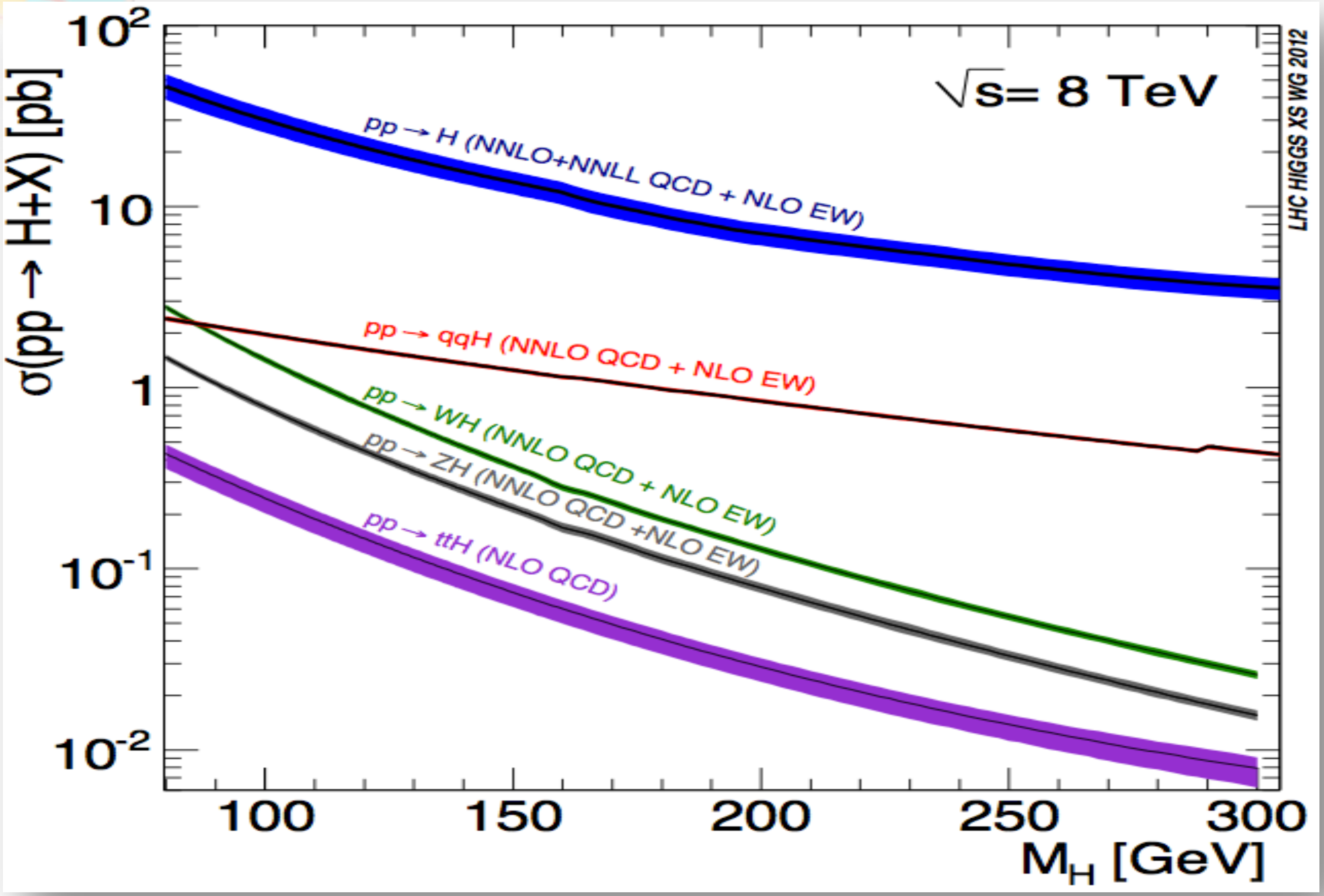
Most recent electroweak and top cross-section measurements

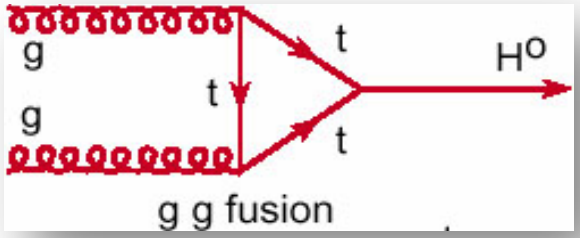


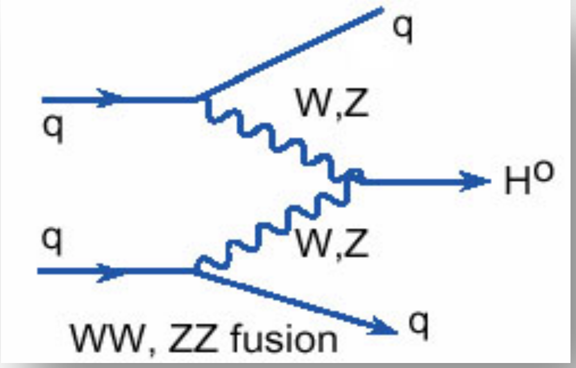
Inner error: statistical
Outer error: total

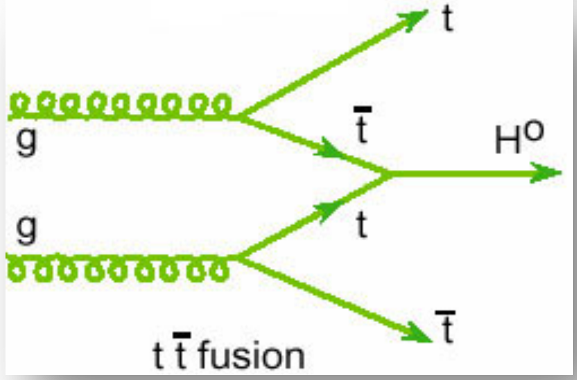
- Important on their own and as foundation for Higgs searches
- Most of these processes are reducible or irreducible backgrounds to Higgs
- Reconstruction and measurement of challenging processes (e.g. fully hadronic tt, single top, ..) are good training for some complex Higgs final states

Higgs boson production







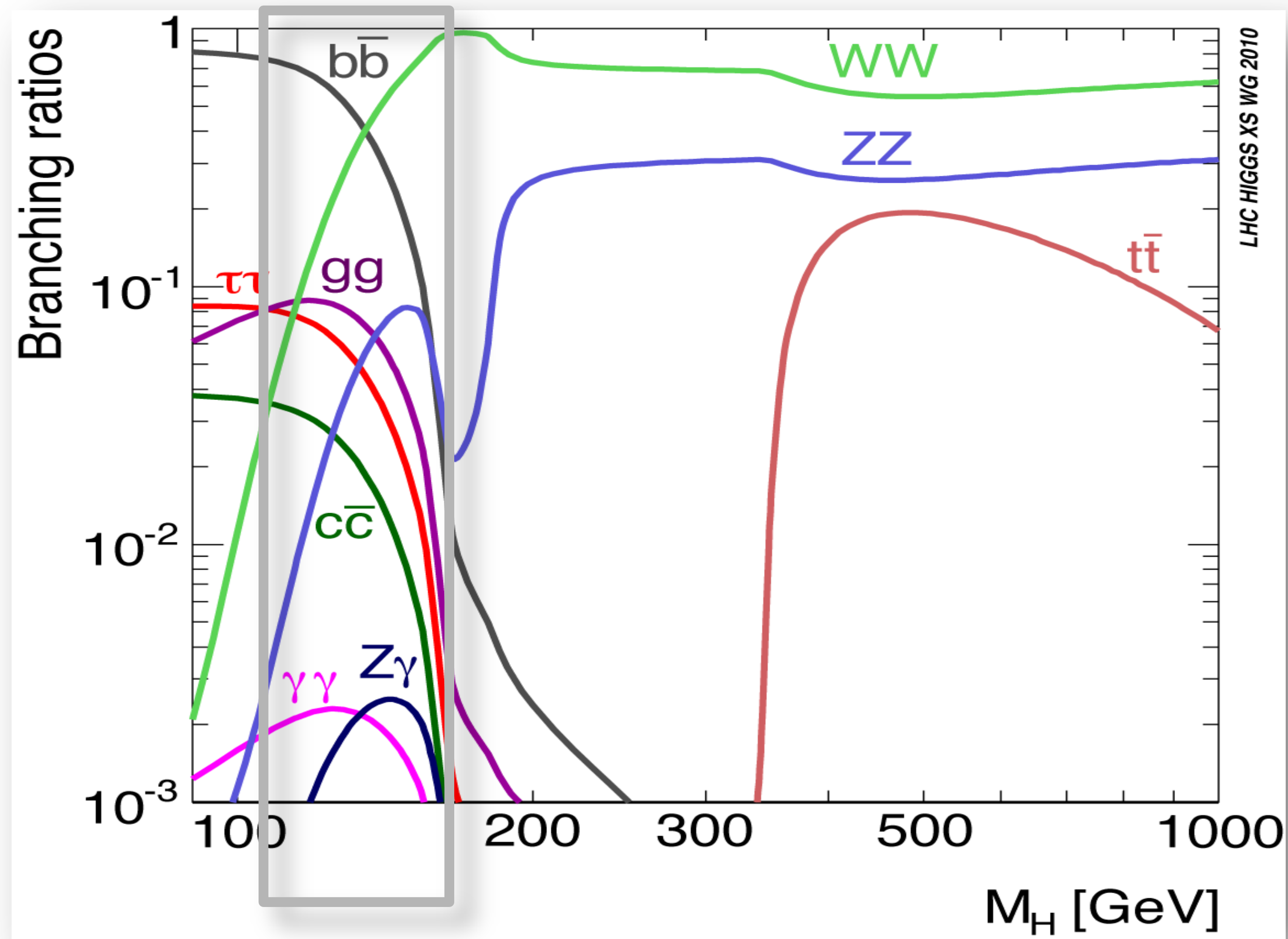


- $\sqrt{s}$=8 TeV: 25-30% higher σ than $\sqrt{s}$=7 TeV at low m_H
- All production modes to be exploited
  - gg VBF VH ttH
  - Latter 3 have smaller cross sections but better S/B in many cases

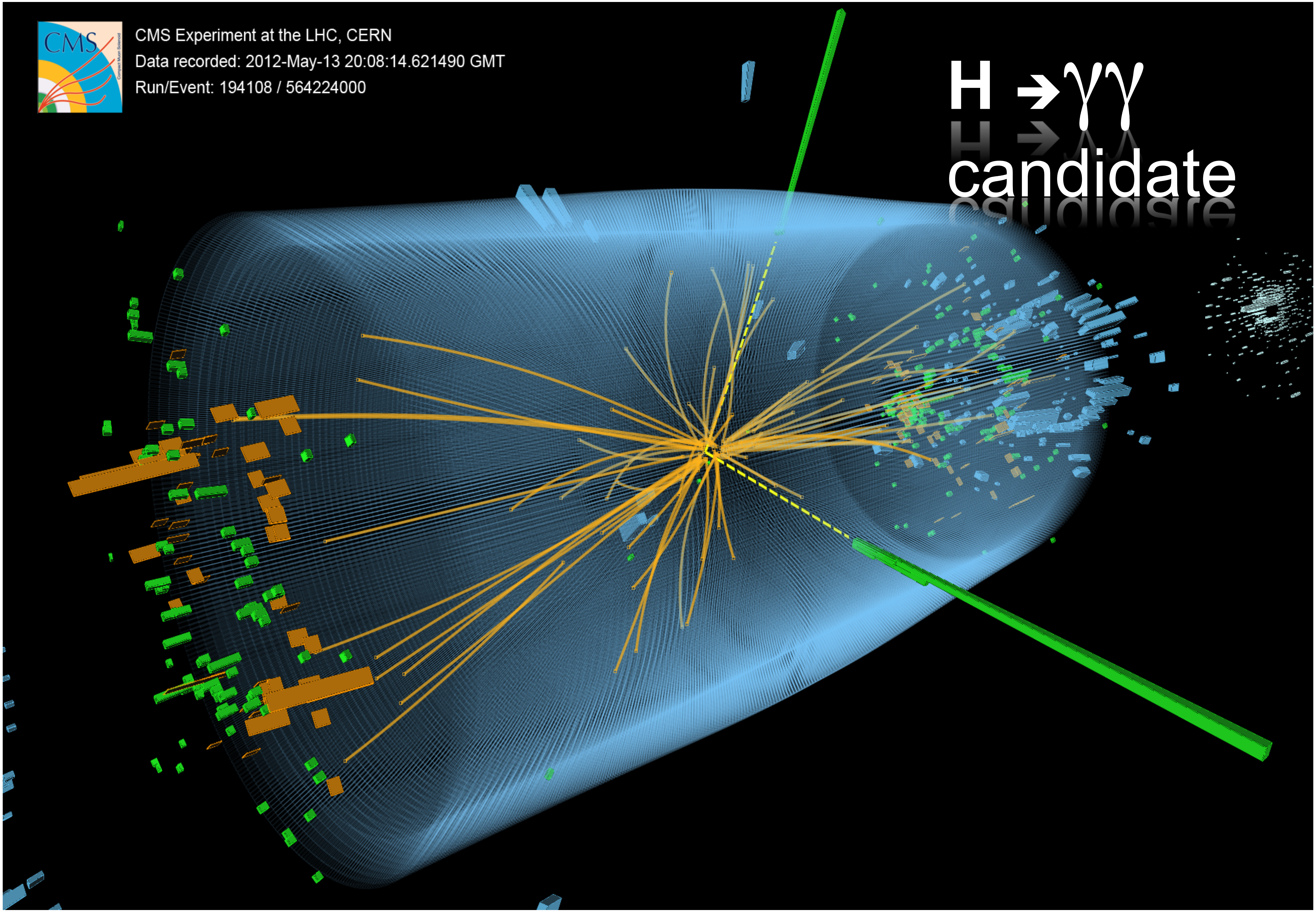
Higgs boson decays

5 decay modes exploited

- High mass: WW, ZZ
- Low mass: $b\bar{b}$, ττ, WW, ZZ, γγ
- Low mass region is very rich but also very challenging:
  main decay modes ($b\bar{b}$, ττ) are hard to identify in the huge background
- Very good mass resolution (1%): H→γγ and H→ZZ→4l

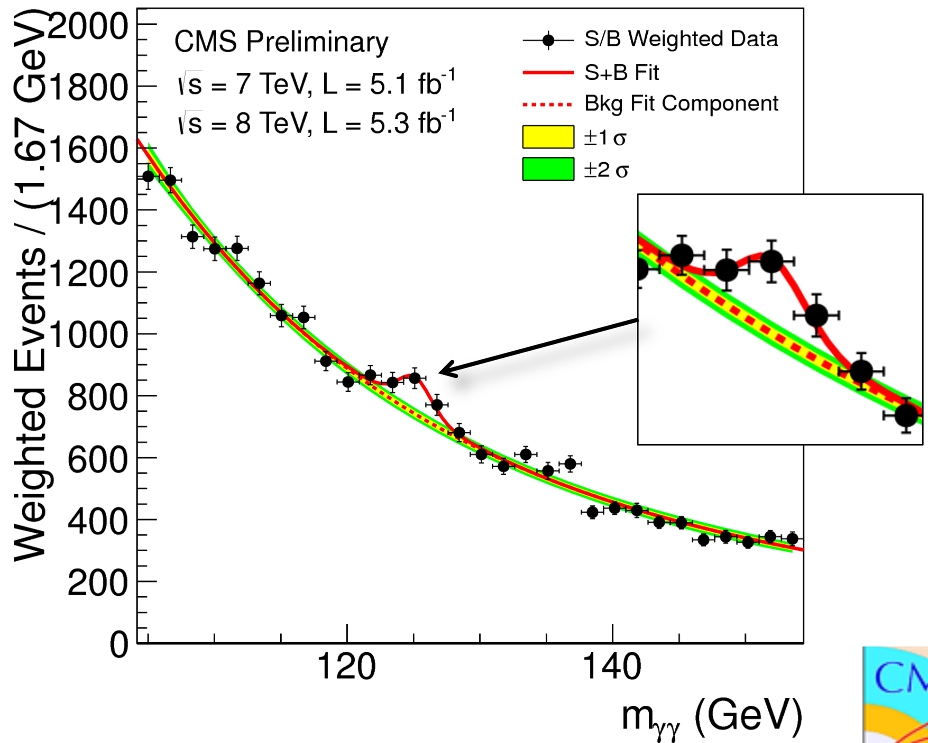


- Le Higgs "aime" se désintégrer dans des particules lourdes…
- … s'il est assez lourd pour cela !


CMS Experiment at the LHC, CERN
Data recorded: 2012-May-13 20:08:14.621490 GMT
Run/Event: 194108 / 564224000
H →γγ
candidate

S/B Weighted Mass Distribution

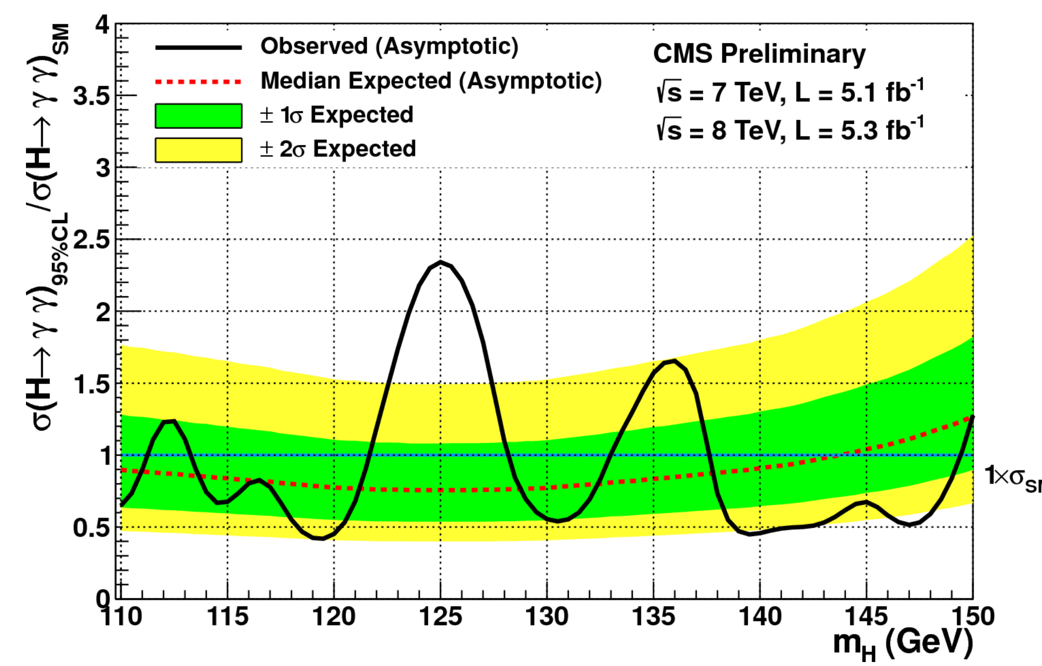
- Sum of mass distributions for each event class, weighted by S/B
  - B is integral of background model over a constant signal fraction interval



On recherche une résonance (i.e. un pic) se désintégrant en 2 photons très énergétiques

Pour chaque $m_H = m_{\gamma\gamma}$, on enlève le bruit de fond, et on en déduit une borne $\sigma(H \rightarrow \gamma\gamma) <$... @ 95%CL qu'on peut comparer au Modèle Standard, et exclure des valeurs de m_H ...

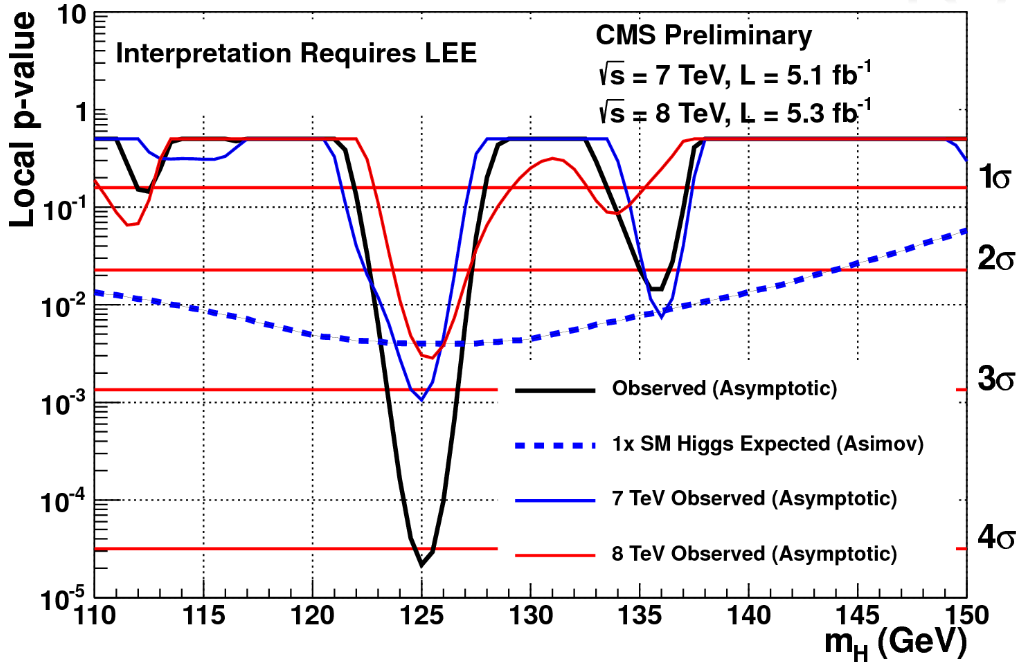
95% CL Exclusion for SM Higgs



- Expected 95% CL exclusion 0.76 times SM at 125 GeV
- Large range with expected excusion below σ_{SM}
- Largest excess at 125 GeV

July 4th 2012 The Status of the Higgs Search J. Incandela for the CMS COLLABORATION

P-Values

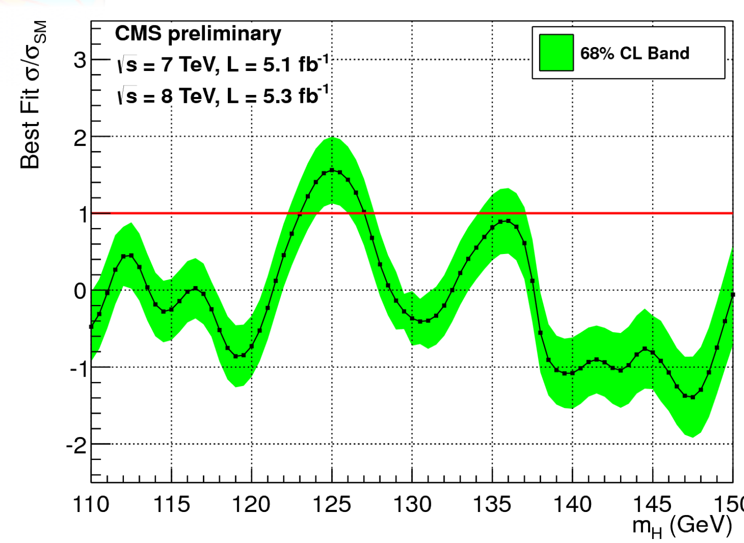


- Minimum local p-value at 125 GeV with a local significance of 4.1 σ
- Similar excess in 2011 and 2012
- Independent cross check analyses give similar results
- Global significance in the full search range (110-150 GeV) 3.2 σ

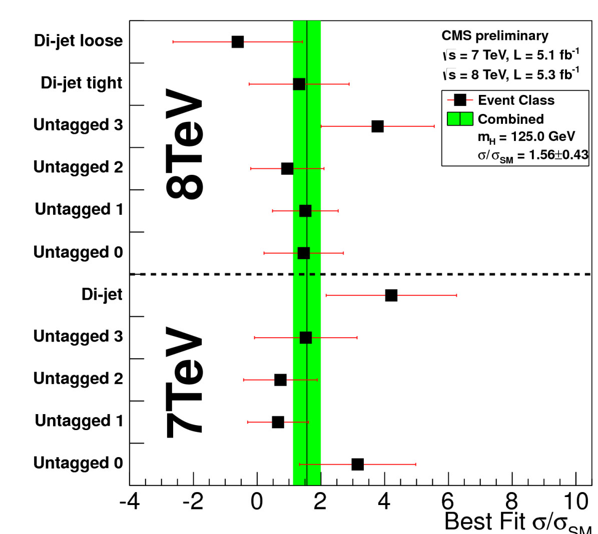
… puis on teste l'hypothèse que la mesure vient uniquement des bruits de fond…

Fitted Signal Strength

… avant de déterminer la section efficace $\sigma(H \rightarrow \gamma\gamma)$ nécessaire pour reproduire le signal

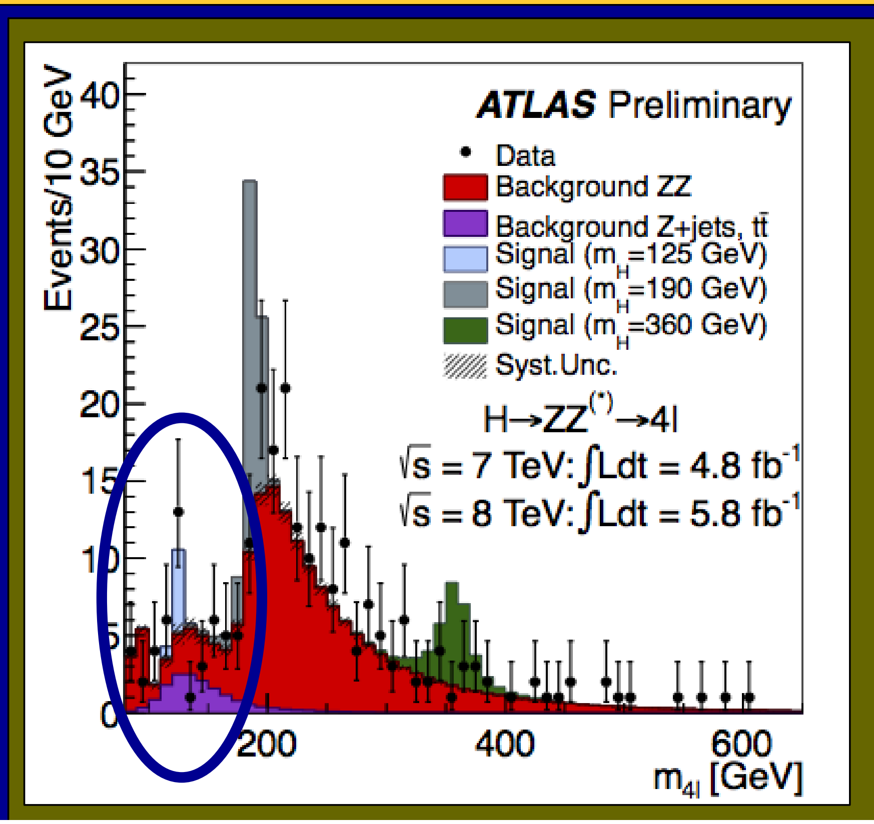


Combined best fit signal strength
σ/σ_{SM} = 1.56±0.43 x SM, consistent with SM.



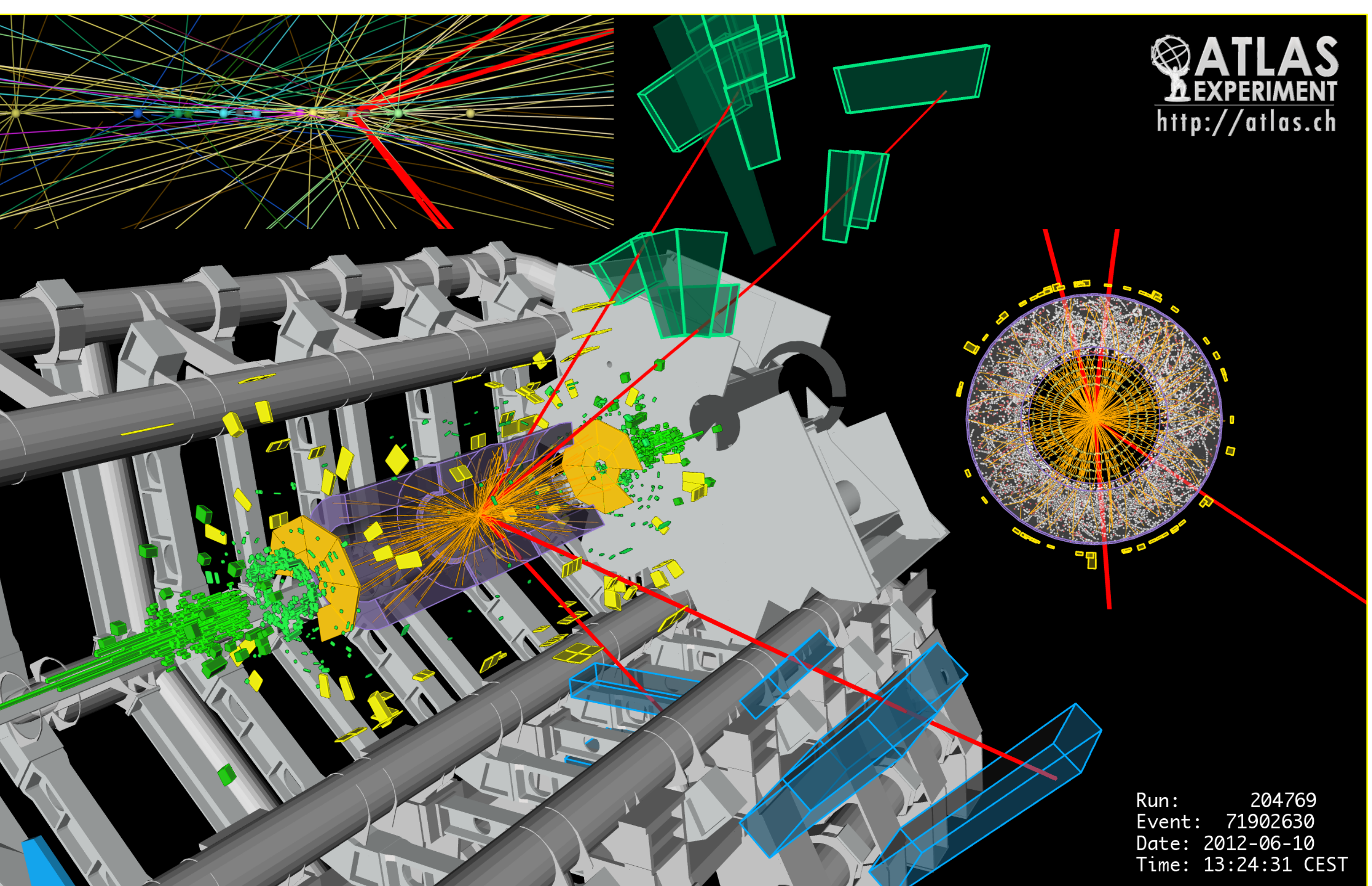
Best fit signal strength consistent between different classes

H→ 4l mass spectrum after all selections: 2011+2012 data



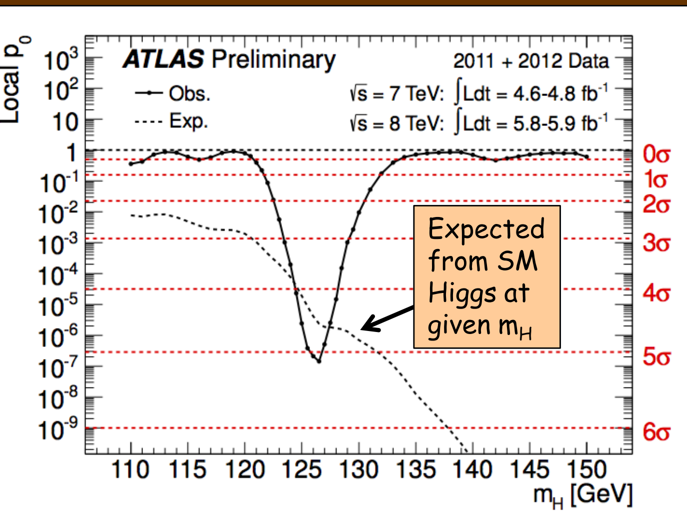
4μ candidate with $m_{4\mu}$= 125.1 GeV

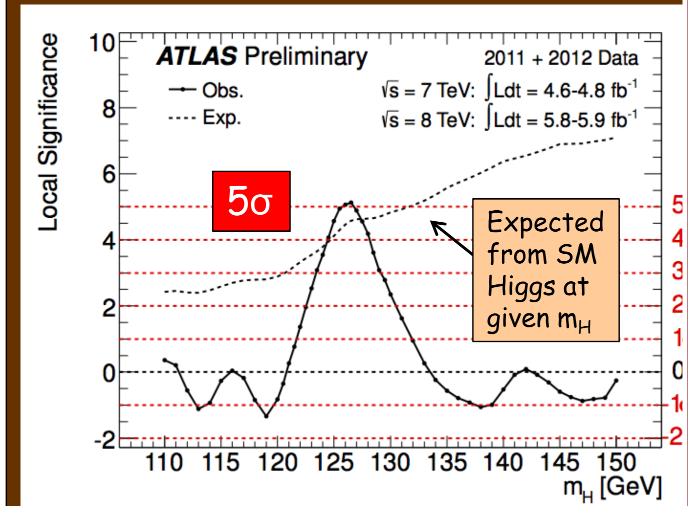
p_T (muons)= 36.1, 47.5, 26.4, 71 .7GeV m_{12}= 86.3 GeV, m_{34}= 31.6 GeV
15 reconstructed vertices



- Approches similaires d'ATLAS et CMS
- D'autres canaux étudiés:
  - une autre indication dans $H \to ZZ^* \to 4\ l$ ($l=e,\mu$)
  - d'autres canaux pas encore compétitifs, mais à étudier: $H \to WW \to l\nu l\nu$, $VH \to Vbb$, $H \to \tau\tau$...
- Et combinés dans une analyse globale

Combined results: the excess



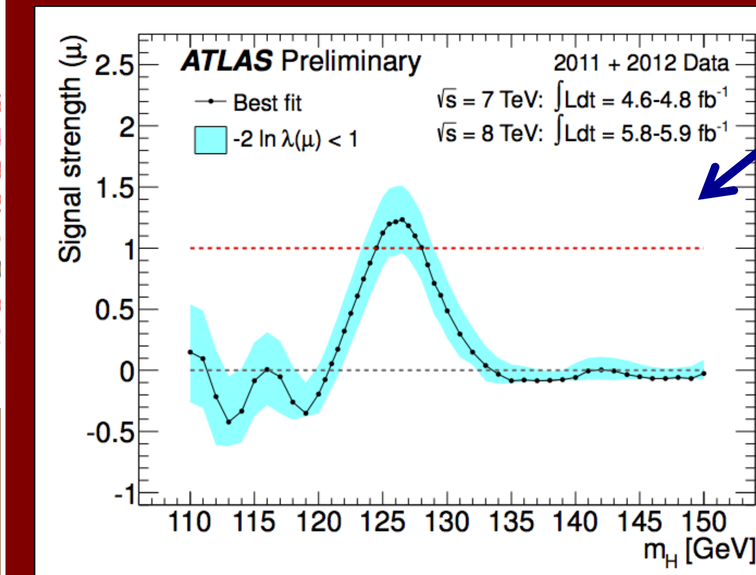


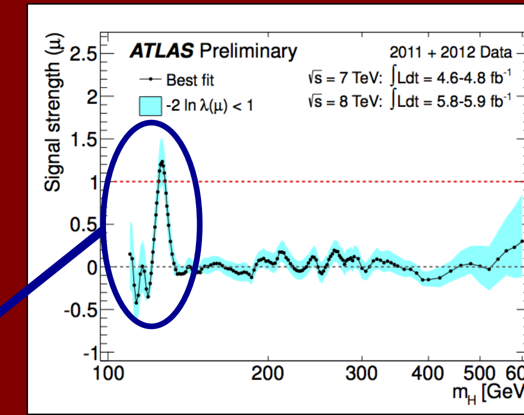
Maximum excess observed at	m_H = 126.5 GeV
Local significance (including energy-scale systematics)	5.0 σ
Probability of background up-fluctuation	3×10^{-7}
Expected from SM Higgs m_H=126.5	4.6 σ

Global significance: 4.1-4.3 σ (for LEE over 110-600 or 110-150 GeV)

Combined results: fitted signal strength

Normalized to SM Higgs expectation at given m_H (μ)

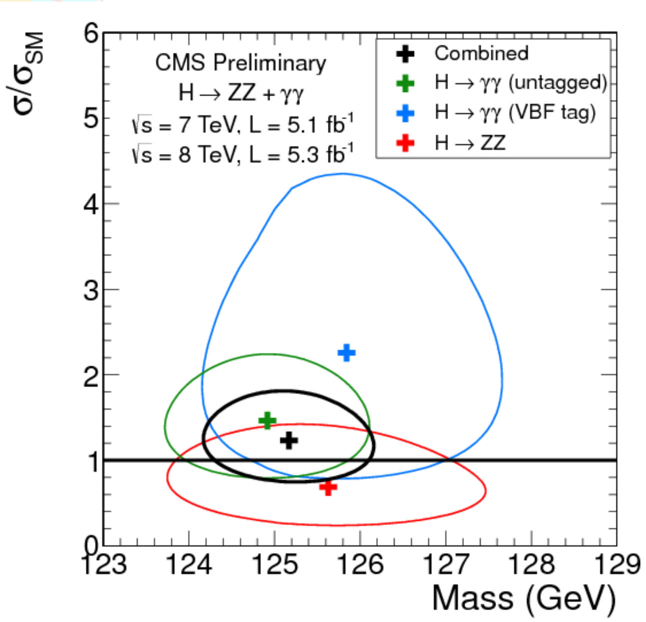




Best-fit value at 126.5 GeV: μ = 1.2 ± 0.3

Good agreement with the expectation for a SM Higgs within the present statistical uncertainty

Characterization of the excess: mass



- Likelihood scan for mass and signal strength in three high mass resolution channels
- results are self-consistent and can be combined

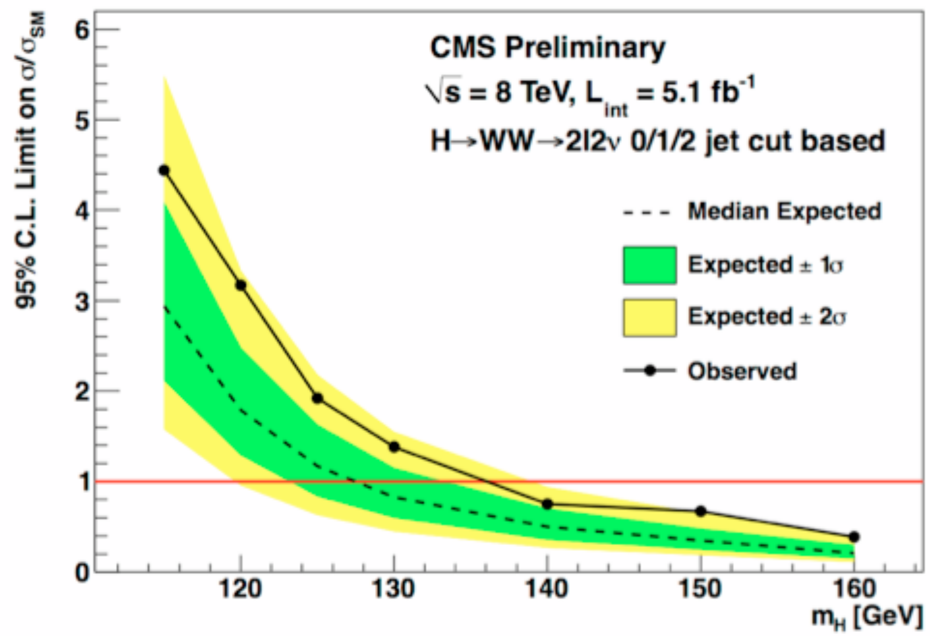
- CMS: 125.3 ± 0.6 GeV (4.9σ) ATLAS ≃ 126.5 GeV (5.0σ)
- Section efficace OK avec les attentes du MS pour Higgs
- Plus à vérifier (spin, autres canaux, couplages...)

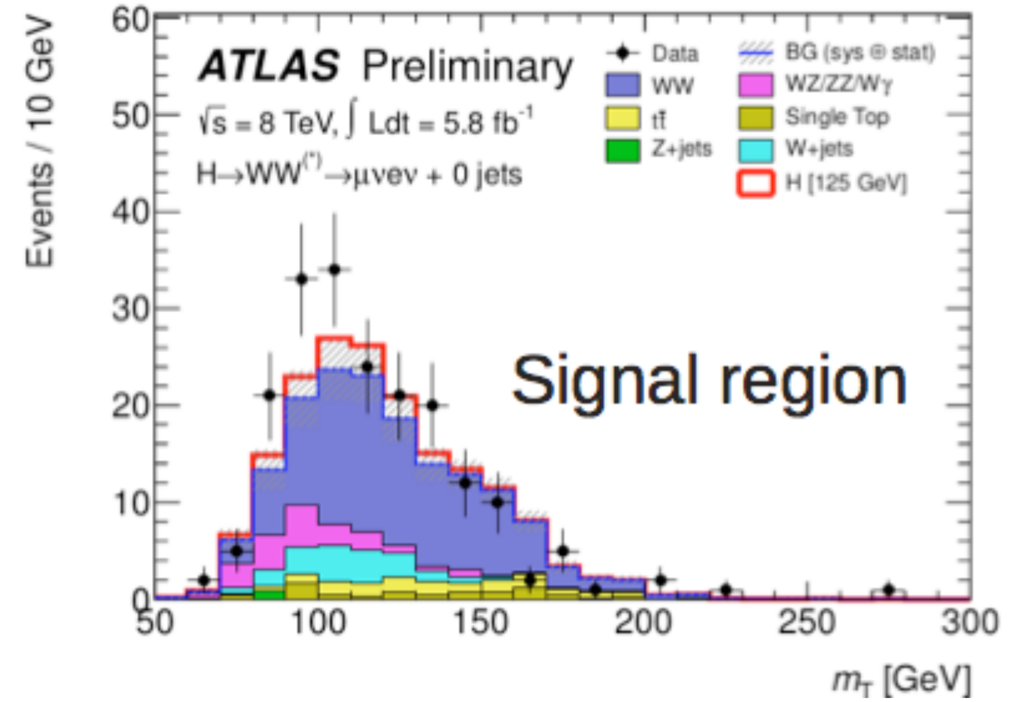
Higgs Hunting 2012

18-20 Juillet 2012, Orsay, France (non ? si !)

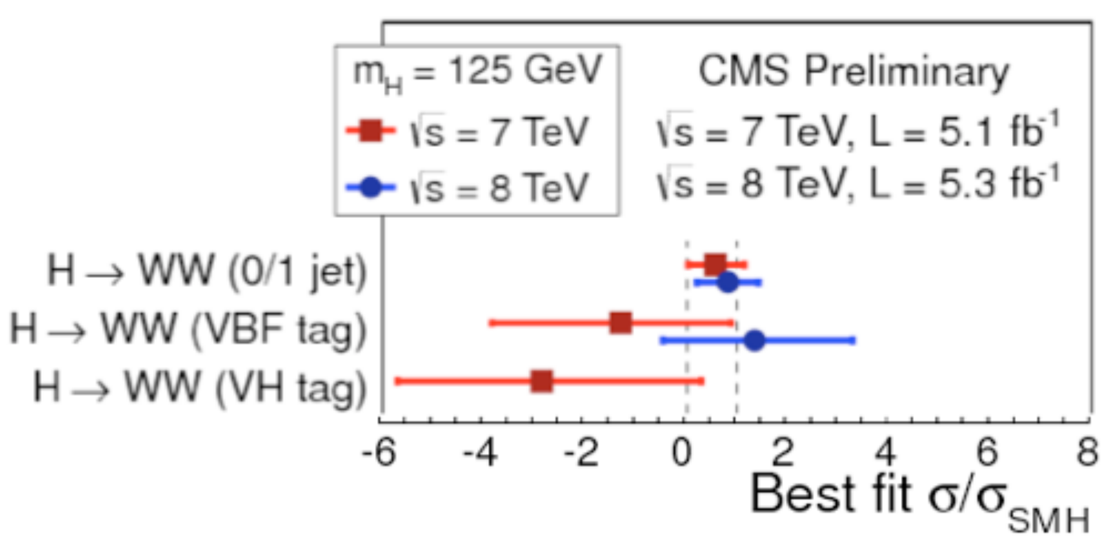
H→WW(*)→ leptons

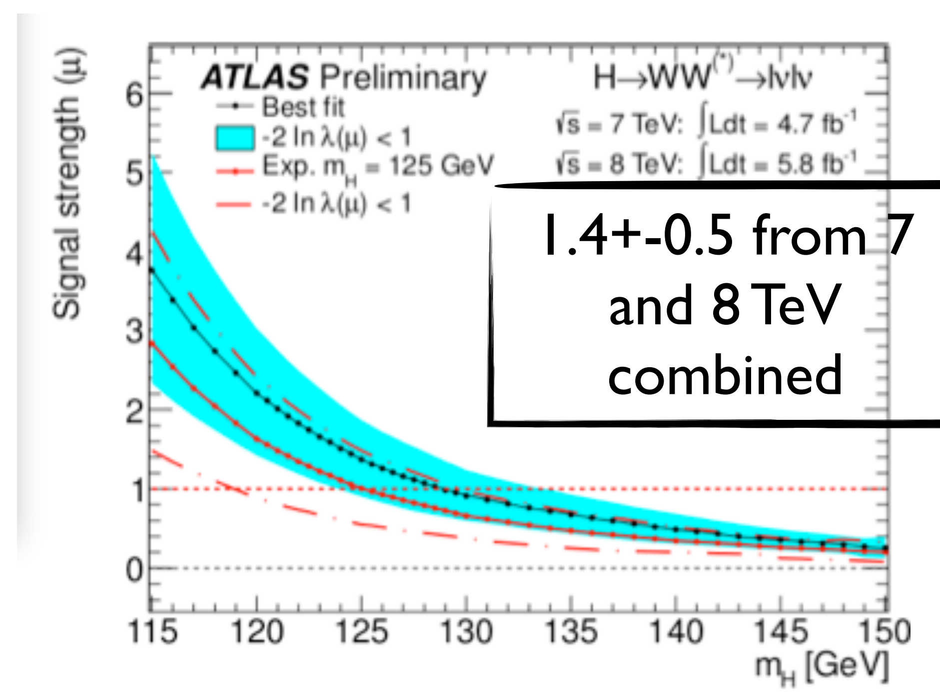
Limit worse than expected for bkg only, consistent with 125 GeV signal, ~1.5 sigma effect





~2.8 sigma excess for combined 7 and 8 TeV



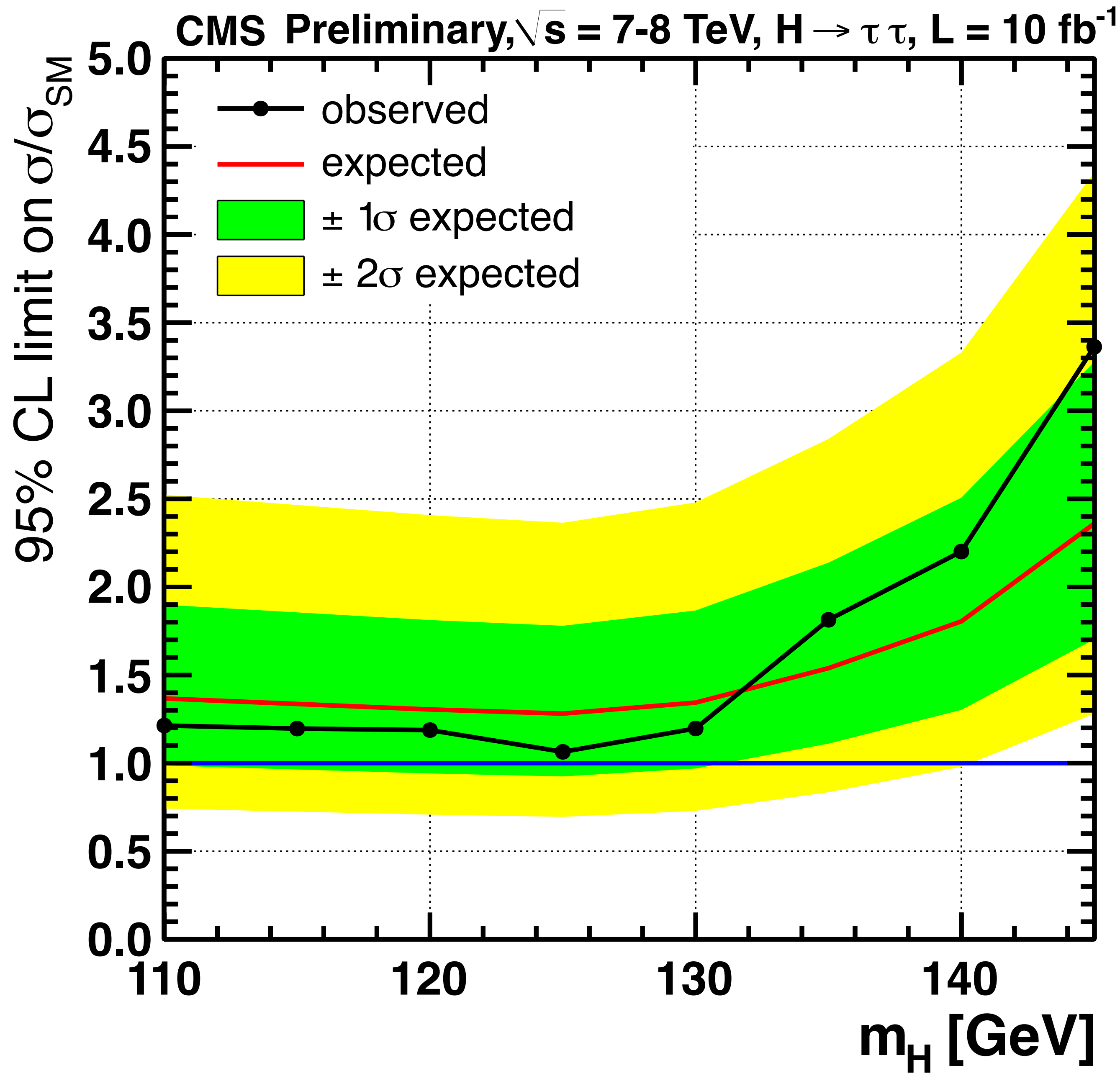


1.4+-0.5 from 7 and 8 TeV combined

Background systematics likely to be critical for improvement of rate measurement
Not yet real sensitivity to SM in VBF production

H→ττ

CMS 95%CL limit sensitivity from 7+8 TeV samples ~ 1.3*SM
Observed limit ~1.06
To be watched....

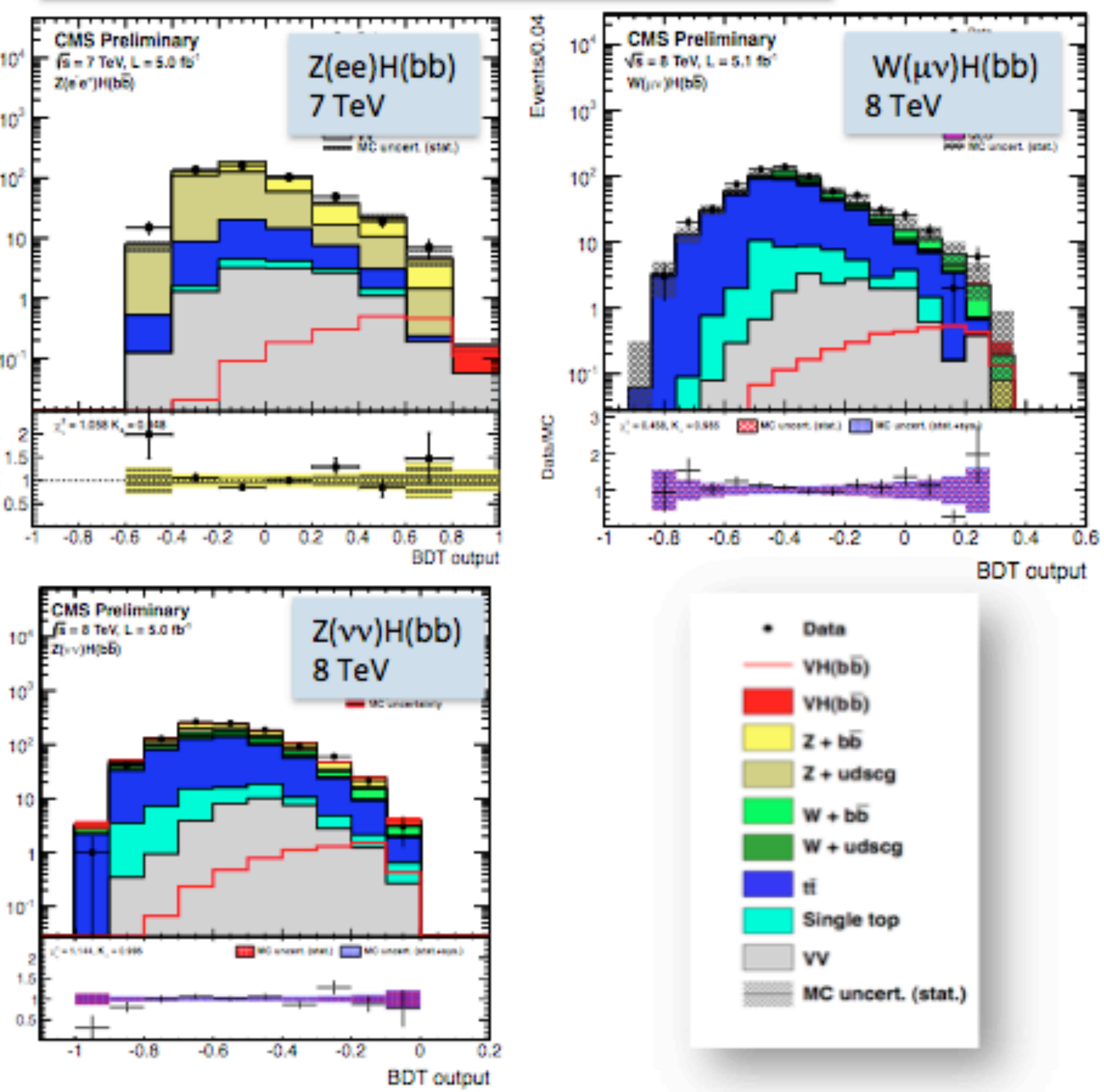


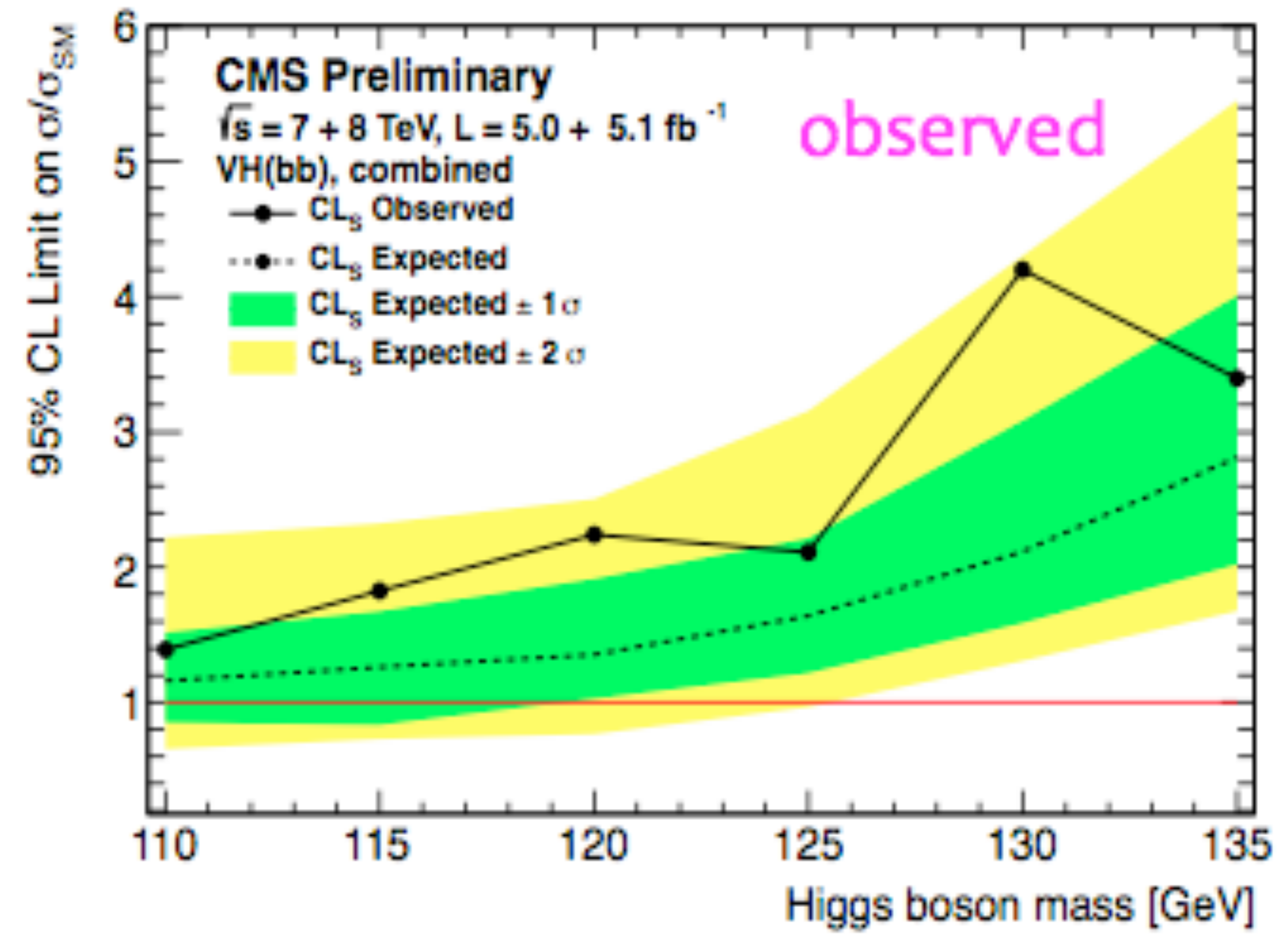
ATLAS 95%CL limit sensitivity with 7 TeV only analysis ~3.5*SM

H→bb

CMS results from 7+8 TeV samples

Examples of BDT distributions



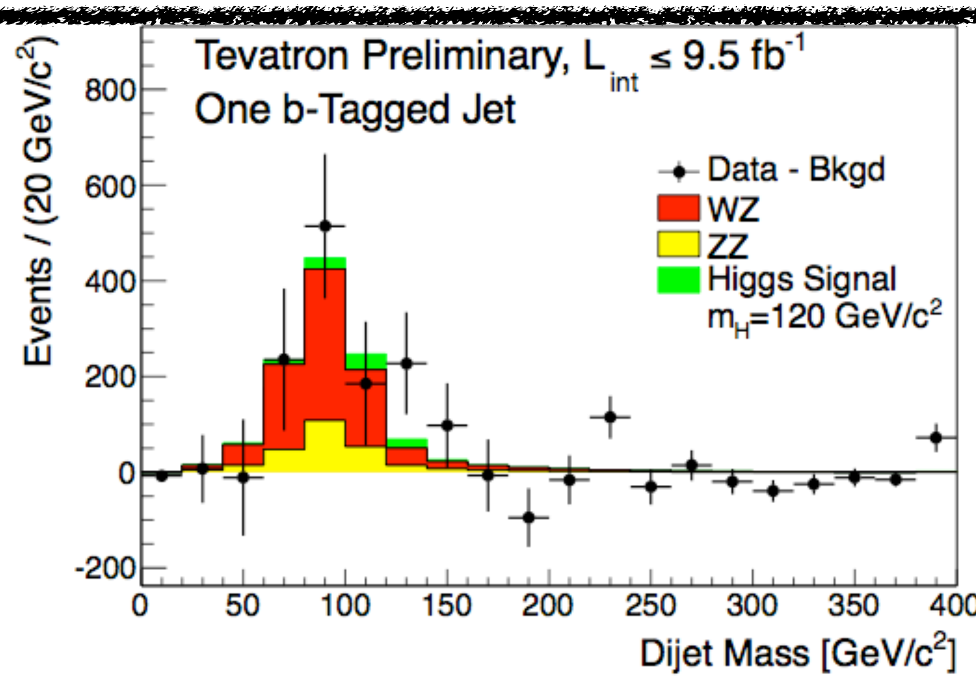


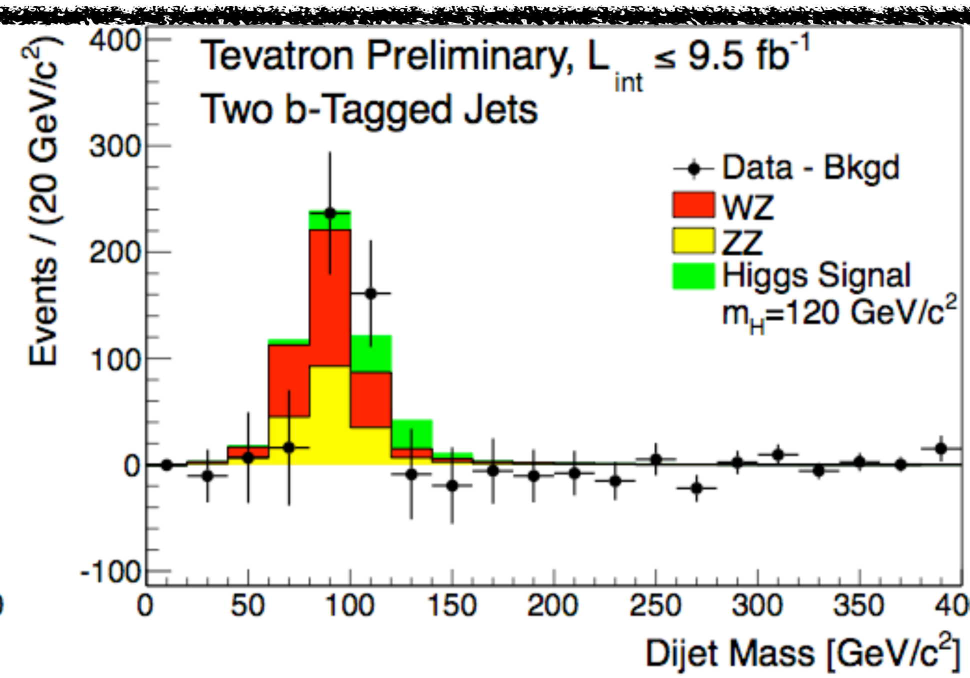
Consistent with S or S+B
slight excess looks like expected for S+B

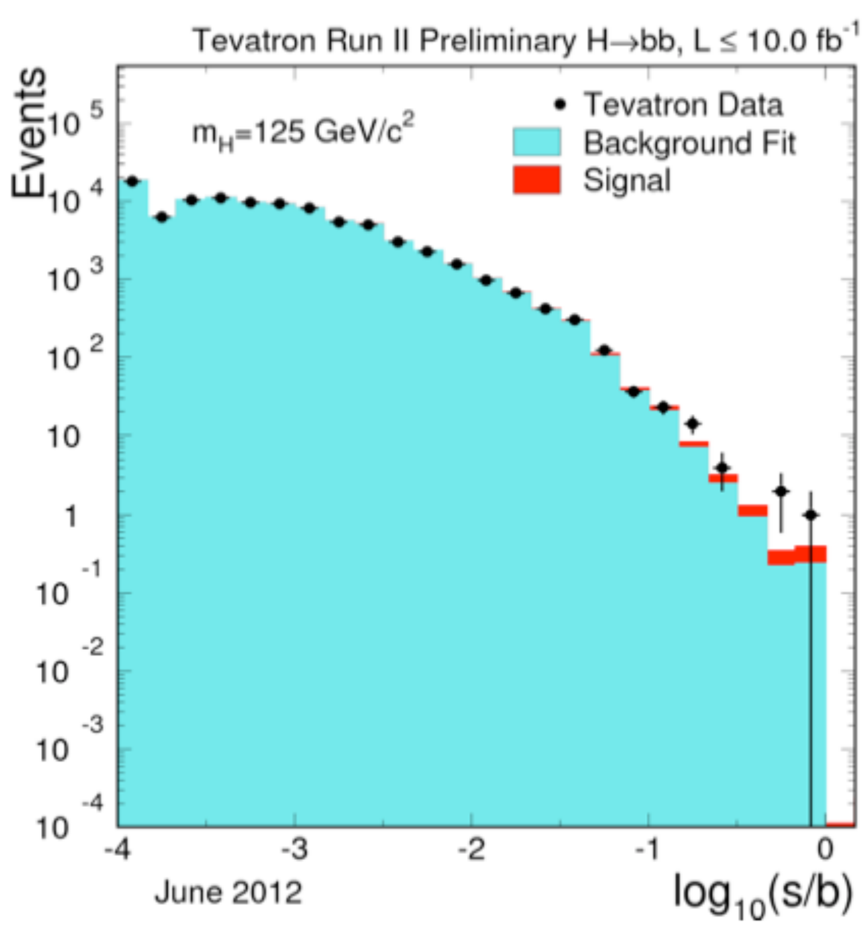
ATLAS sensitivity with 7 TeV sample ~ 4*SM

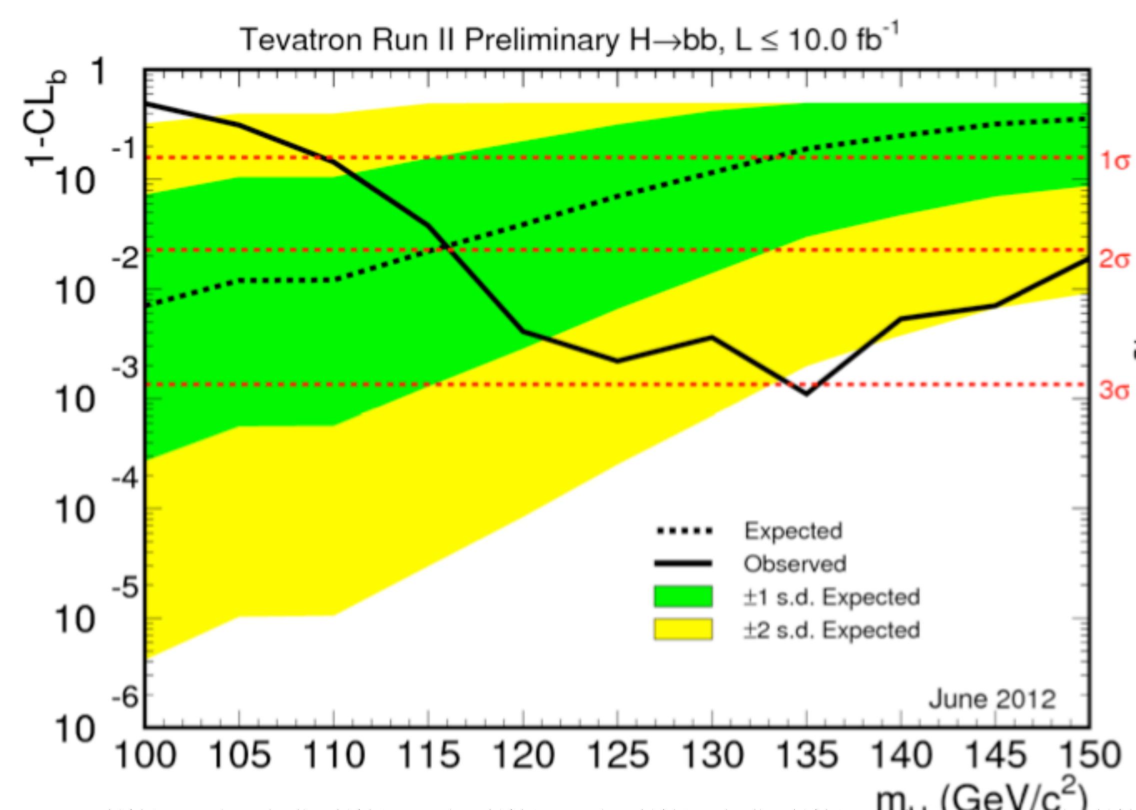
Tevatron results

Background (except WZ,ZZ) subtracted mass distribution (slightly less statistics)









~ 3 sigma deviation from bkg only
Signal rate ~ 2*SM (~1.5 sigma from SM)

Conclusions

A new boson with mass ~125 GeV is observed at LHC, looking «close» to the Standard Model scalar boson

This is the outcome of many years of preparation of the LHC, the experiments (design, R&D, construction, test-beam, preparatory work) and very successful LHC and detector operations since 2010 and also many theoretical progresses in understanding Higgs production and decay

Short term questions:

- Is the rate to gamma-gamma really higher than SM predictions ?
- Can we see tau-tau decays ?
- Can the b-bbar evidence (higher than SM) from the Tevatron be confirmed ?
- Can we have some first spin/CP indication before the end of the year ?

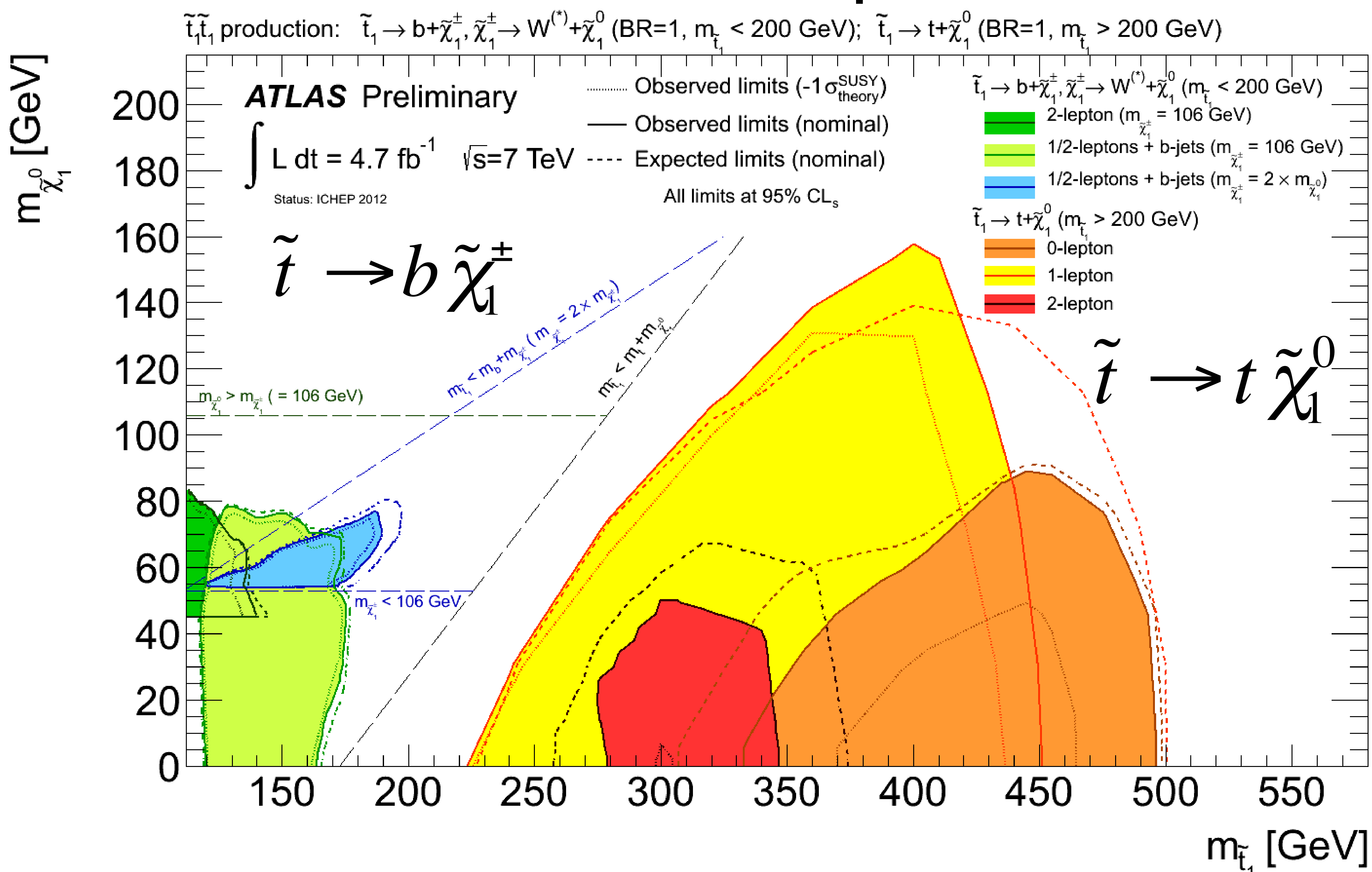
This is of course the beginning of detailed investigations on the properties of this new particle

And also an important input for future collider discussion

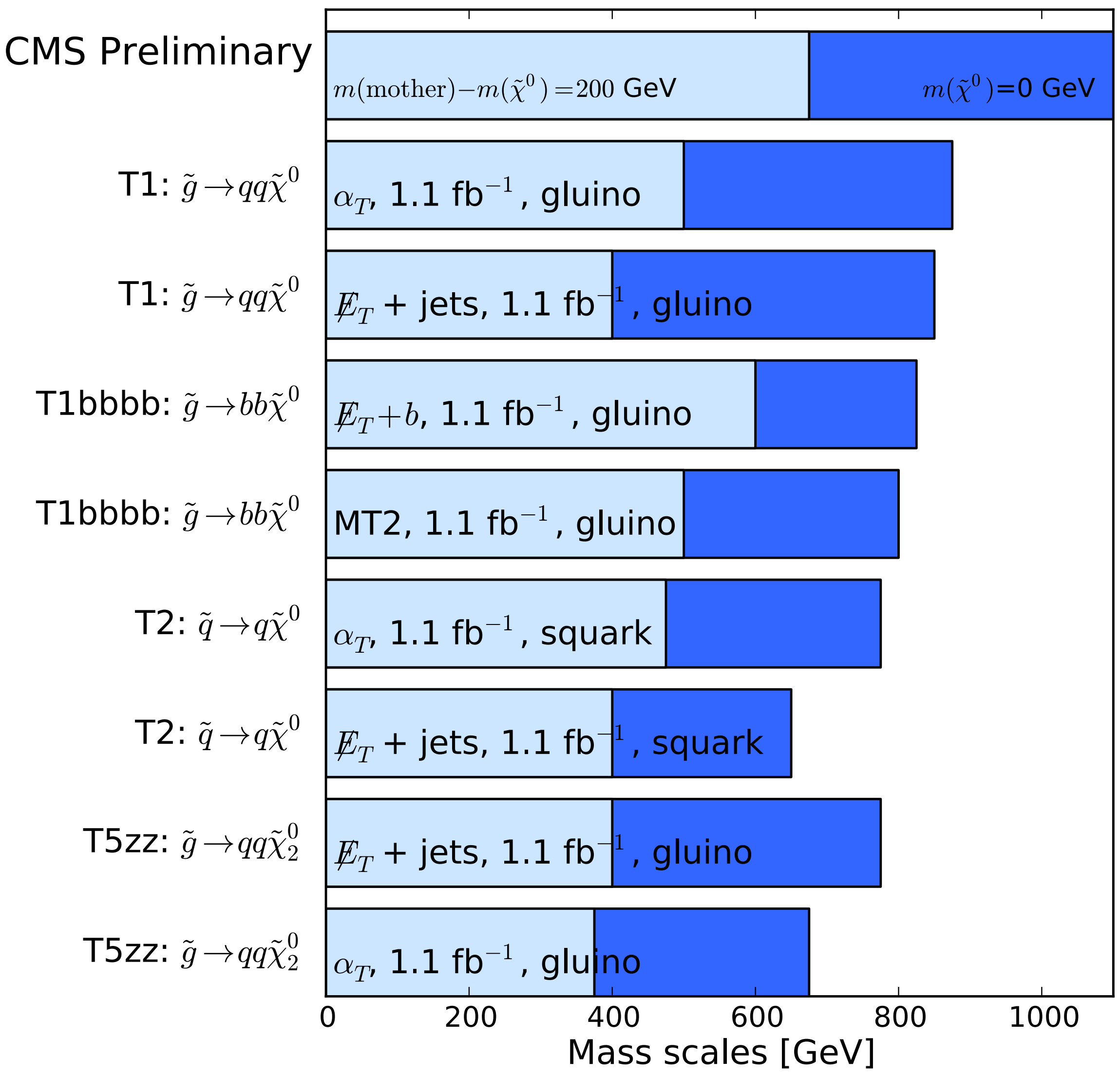
Modèle Standard,
Modèle Standard,
Modèle Standard !

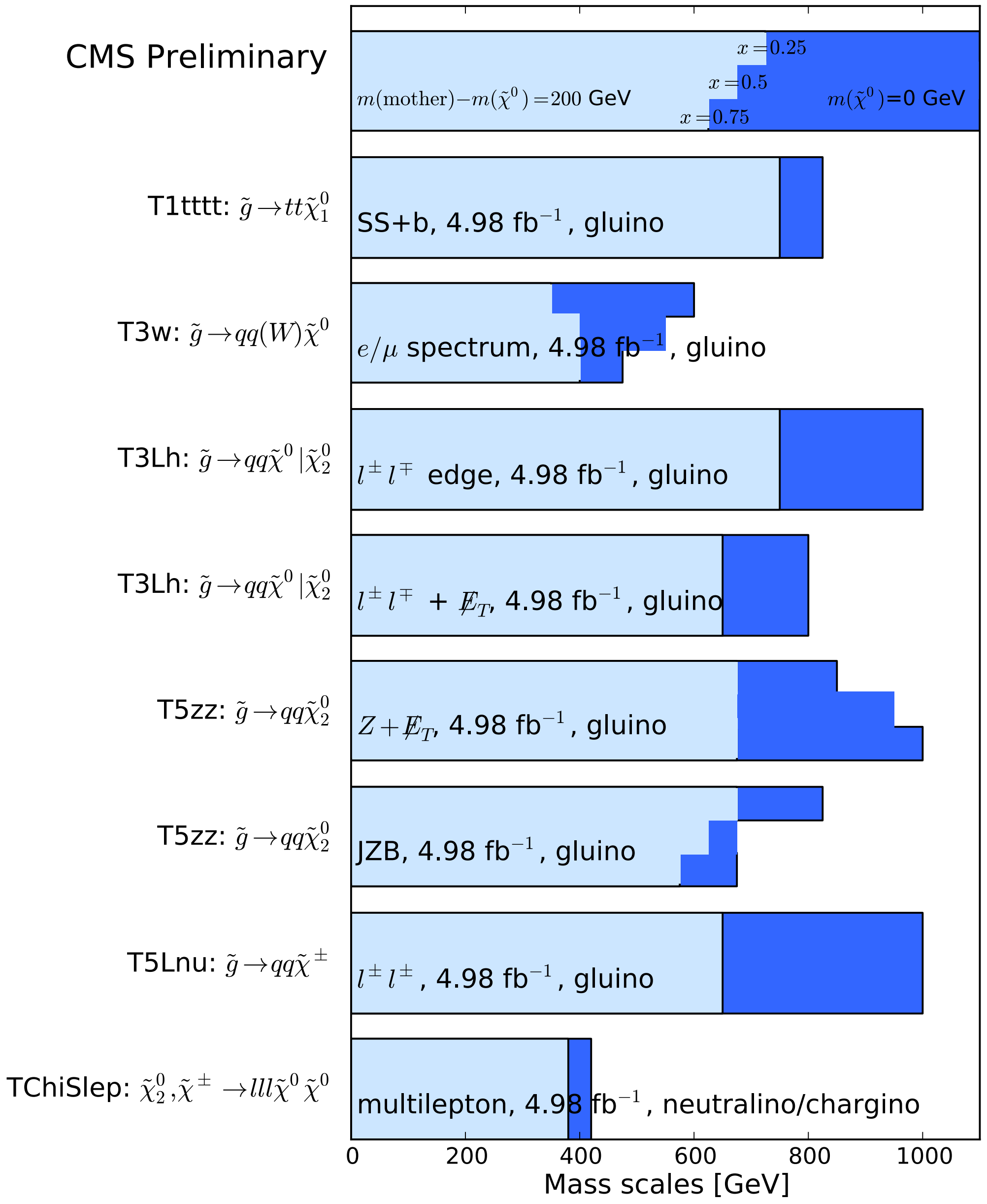
On recherche non seulement les particules du Modèle Standard, mais aussi d'autres particules, en particulier celles prédites par diverses versions de la supersymétrie (par ex, scalar top ou stop)

ATLAS Combined Stop Exclusion



CMS results summary



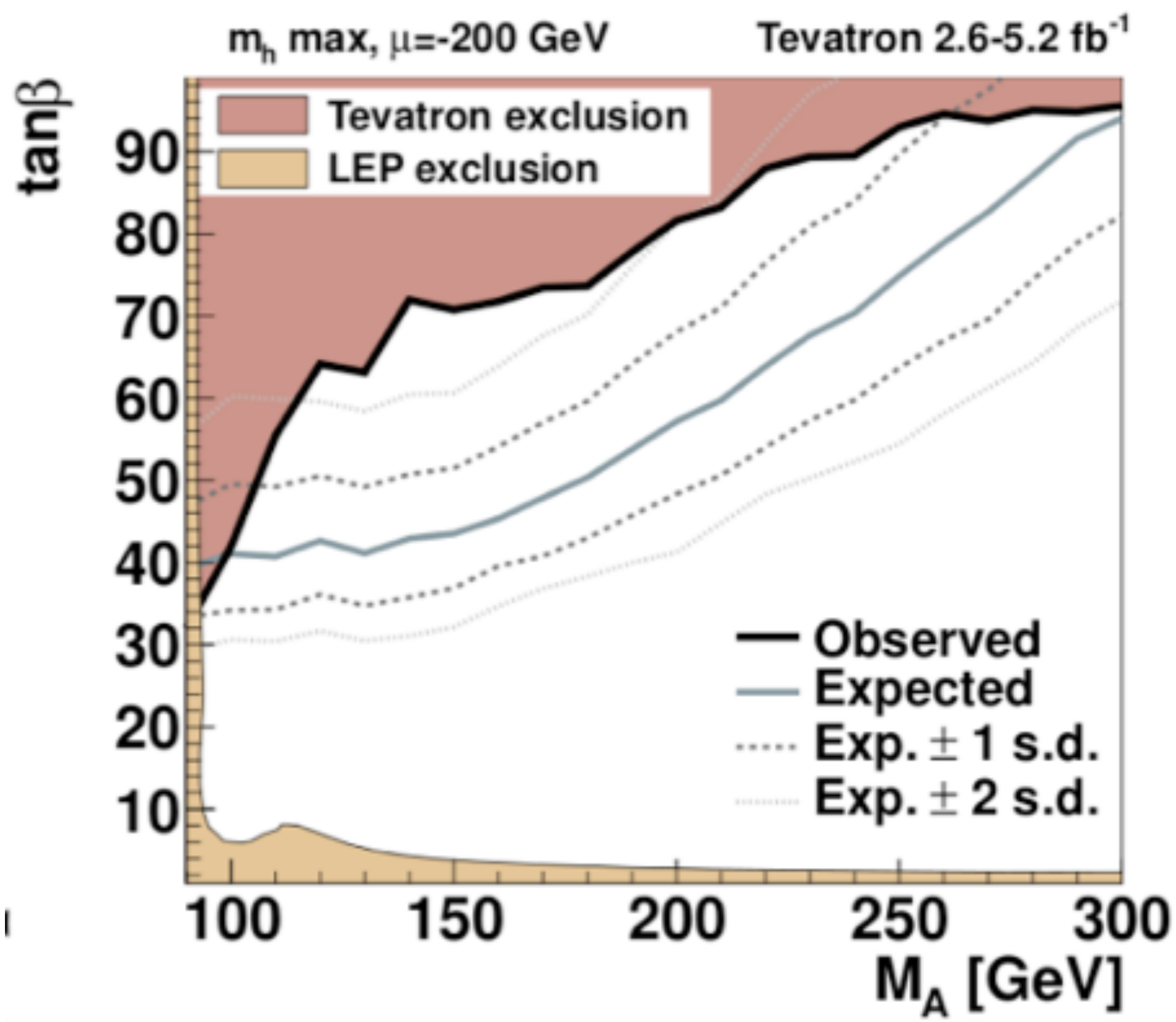


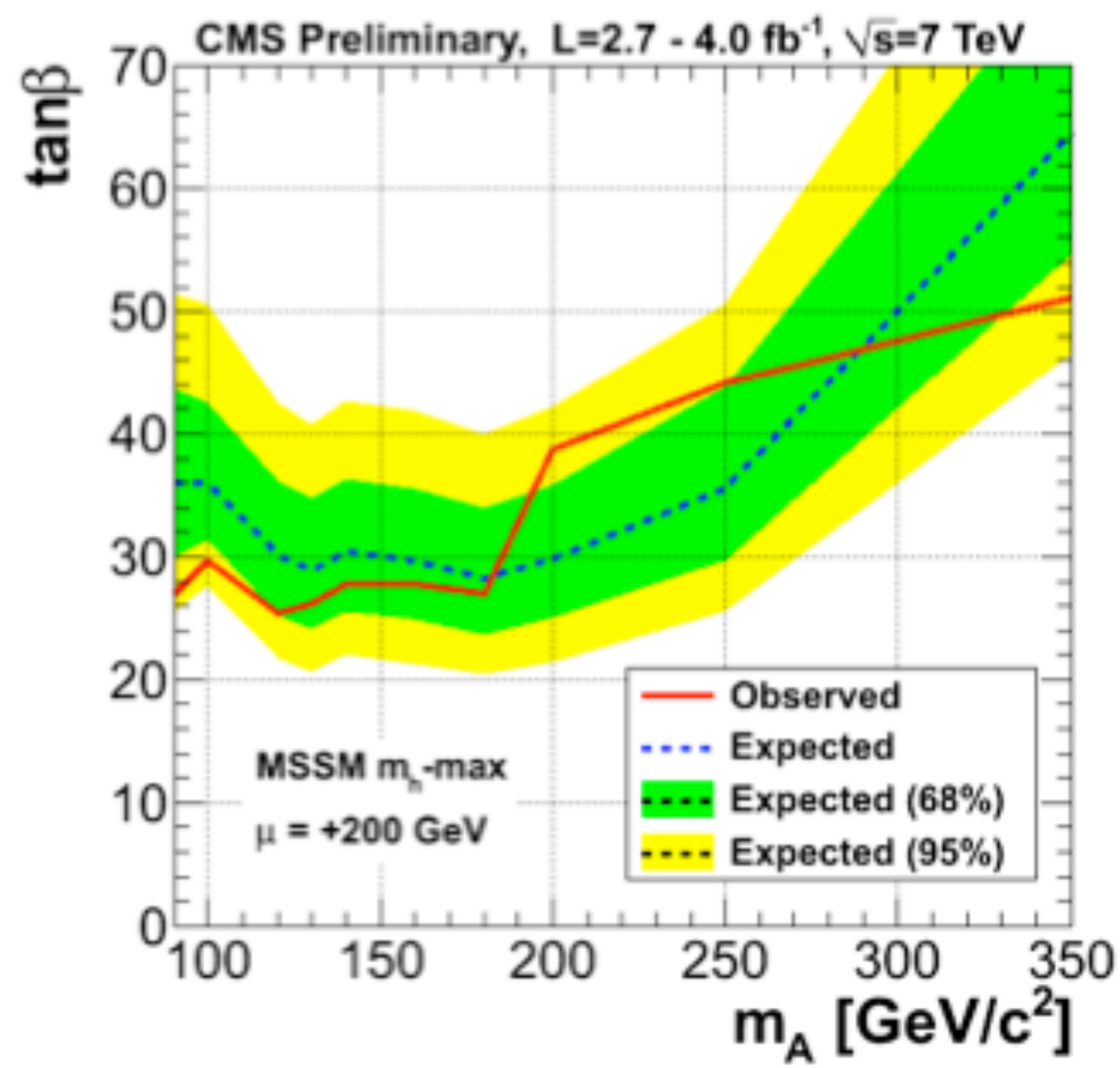
Mais pour l'instant, aucune indication d'une autre particule, hors Modèle Standard, pour les énergies atteintes...

A/H → bb

De même, pas d'indication d'autres Higgs que celui du Modèle Standard (pseudoscalaire, chargé)

Doable in associated production with b => 3 b final





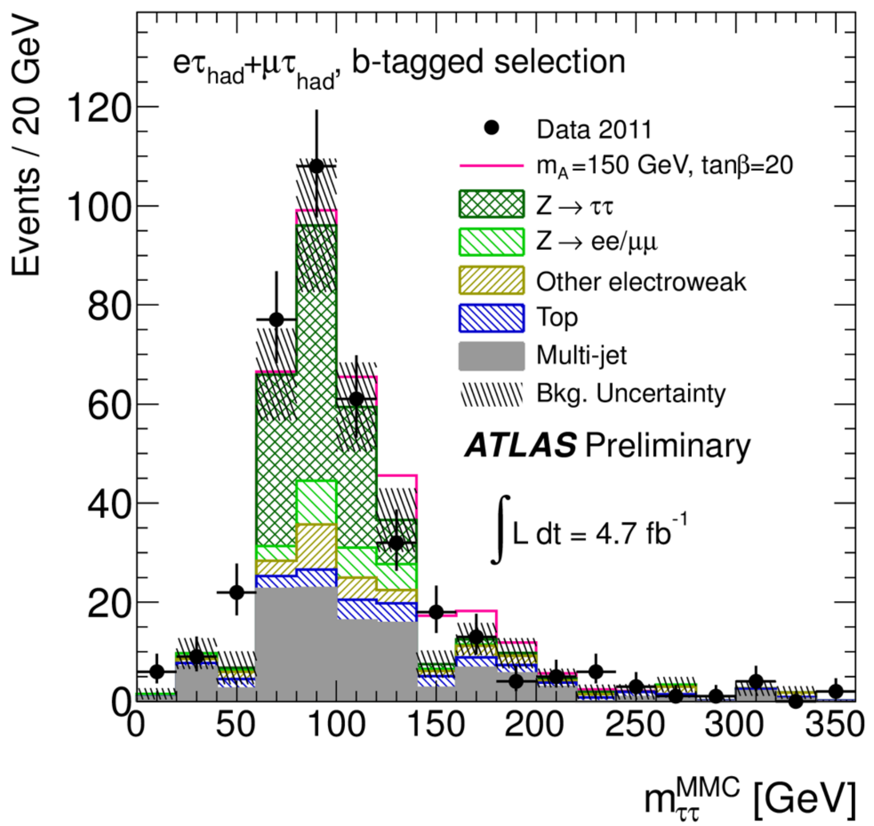
Excess seen in Tevatron (2-3 sigmas) not observed at CMS (and probably excluded in simple models)

A/H →ττ

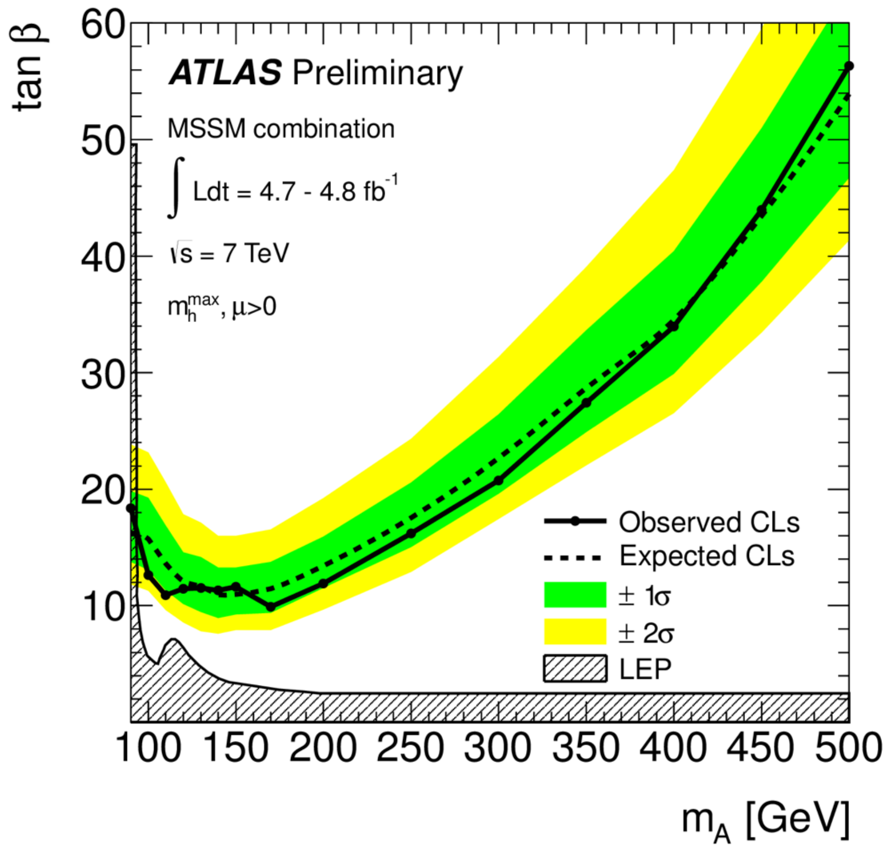
Separate in 0 b-tag and b-tag (associated production)

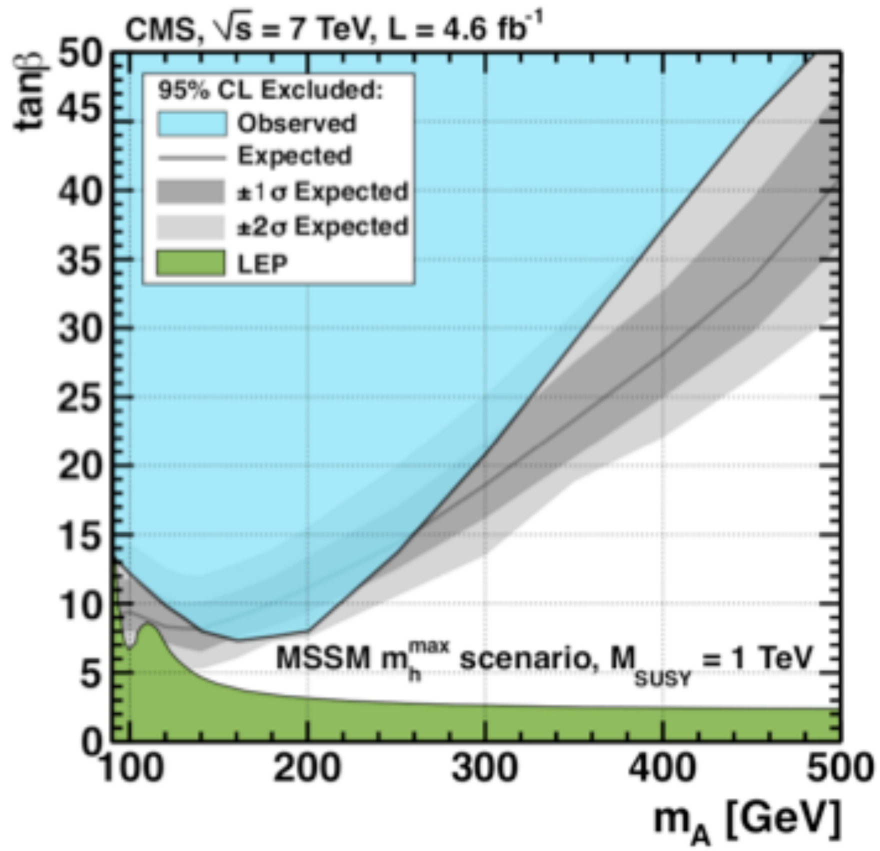
ATLAS use lepton-lepton, lepton-hadron and hadron-hadron tau final states
CMS uses lepton-lepton and lepton-hadron

di-muon final state also looked at H.Weber

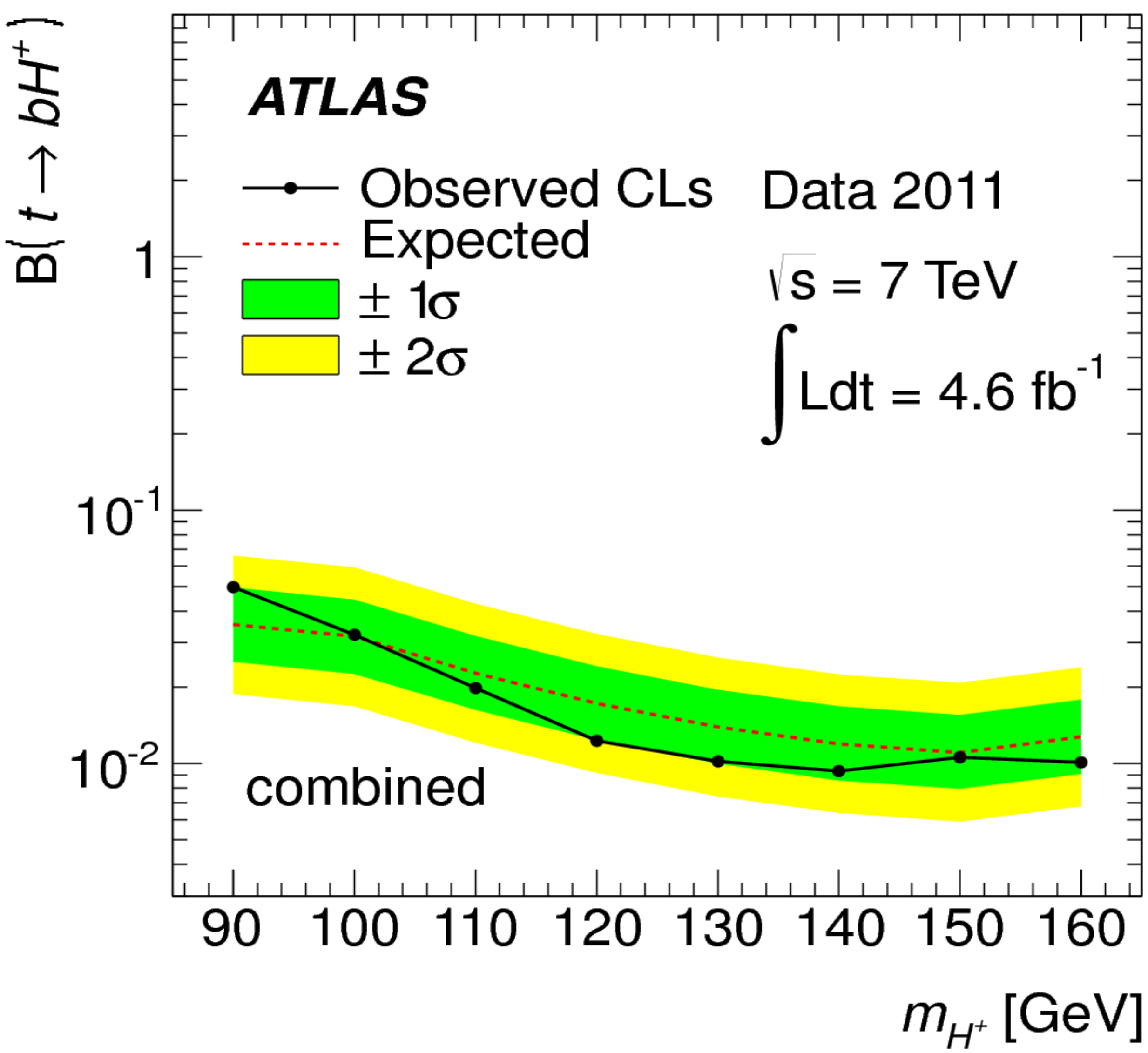


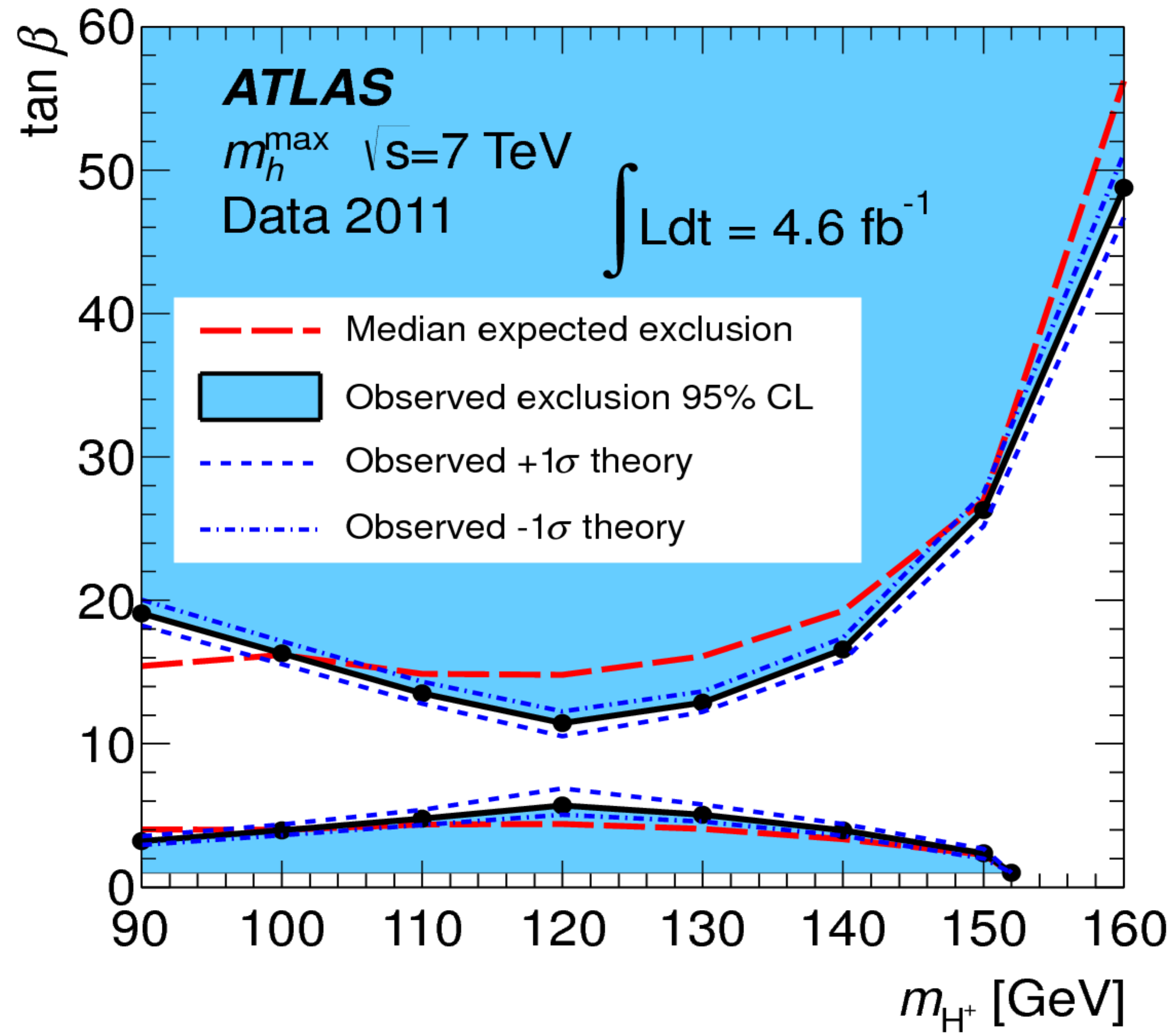
(Tevatron limits reach tan(beta)~20 at MA=150 GeV)





Charged Higgs: Results

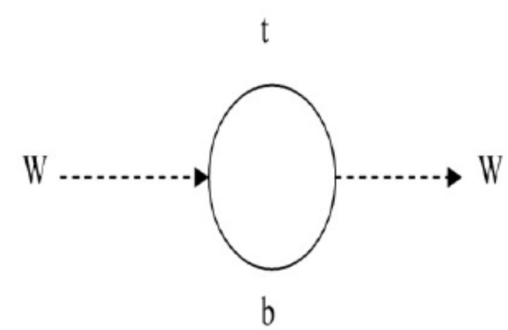




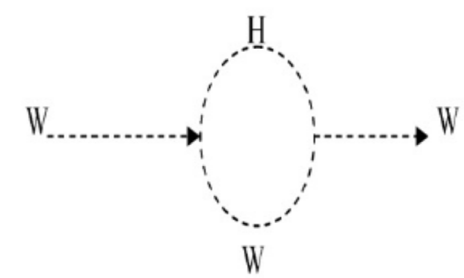
- No significant excess is observed.
- Very little room remaining for a light charged Higgs boson!

Flavor Physics as a NP discovery tool

- While measurements of CKM parameters & masses are fun, the main purpose of Flavor Physics is to find and/or define the properties of physics beyond the SM
- FP probes large mass scales via virtual quantum loops. An example, of the importance of such loops are changes in the W mass
  - M_w changes due to m_t $\quad \dfrac{dM_W}{dm_t} \alpha \dfrac{m_t}{M_w}$



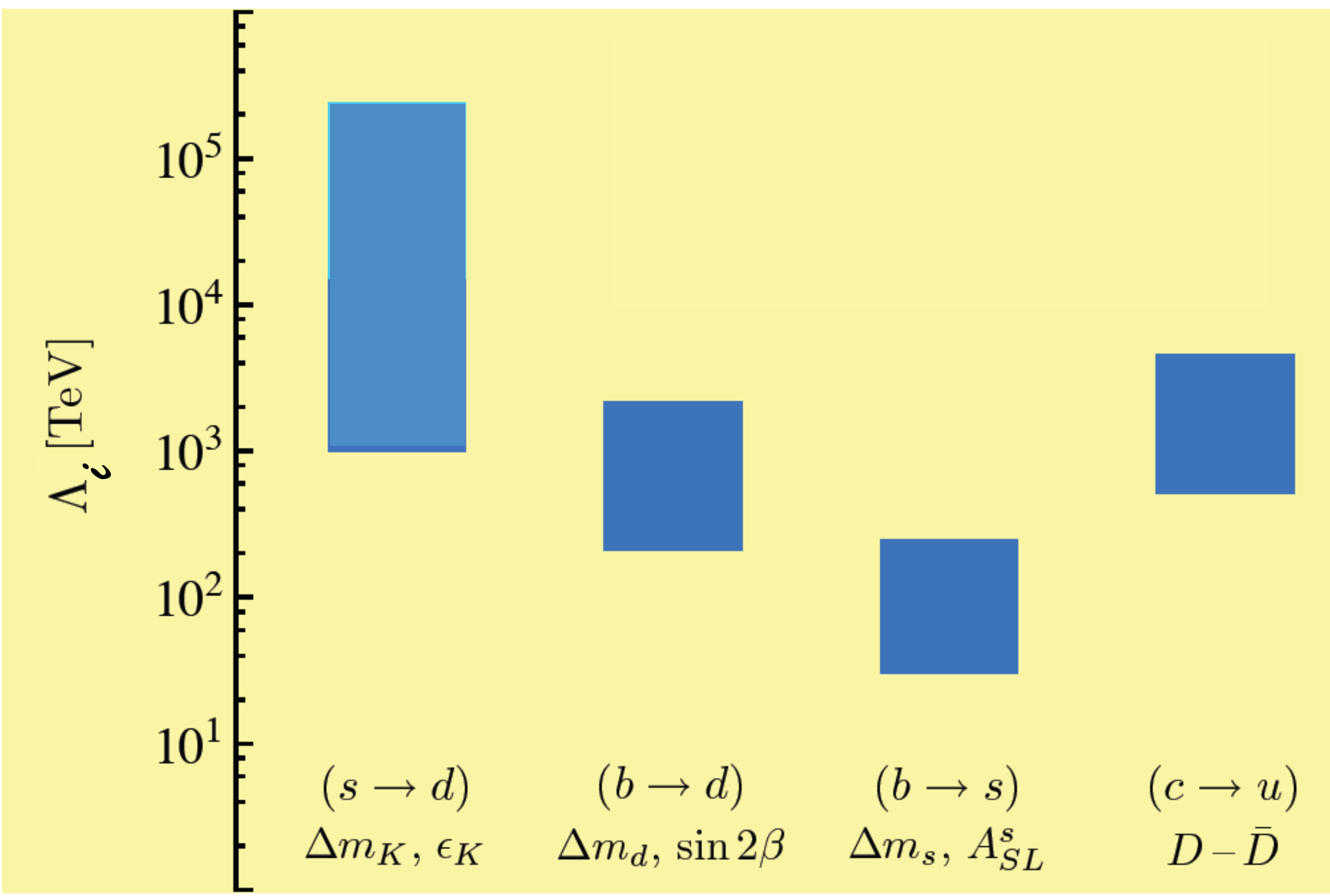
  - M_w changes due to m_H $\quad \dfrac{dM_W}{dm_H} \alpha - \dfrac{dm_H}{M_H}$



On peut se tourner vers des processus de plus basse énergie,
défavorisés dans le Modèle Standard,
et sensibles par des boucles à la Nouvelle Physique...

Flavor as a High Mass Probe

- Already excluded ranges from box diagrams
  - $\mathcal{L}_{\text{eff}} = \mathcal{L}_{\text{SM}} + \frac{c_i}{\Lambda_i} O_i$, take c_i ~1



Ways out

1. New particles have large masses >>1 TeV
2. New particles have degenerate masses
3. Mixing angles in new sector are small, same as in SM (MFV)
4. The above already implies strong constrains on NP

See: Isidori, Nir & Perez arXiv:1002.0900; Neubert EPS 2011 talk

ϕ_s results from J/ψφ

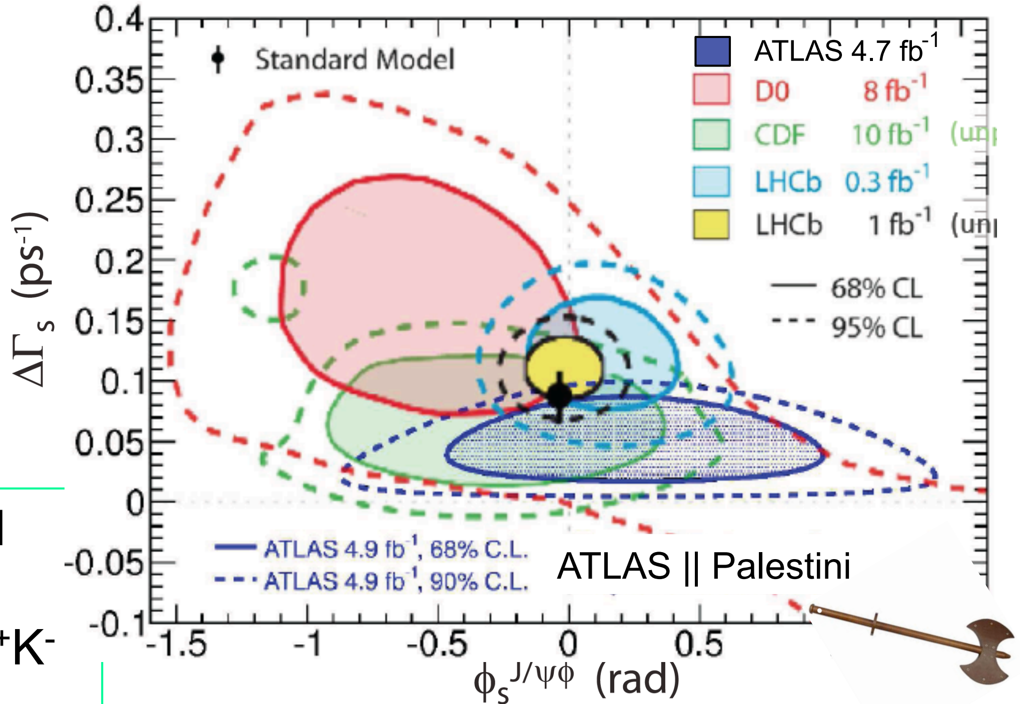
LHCb values

$\Gamma=0.6580\pm0.0054 \pm0.0066\,(ps^{-1})$

$\Delta\Gamma=0.116\pm0.018 \pm0.006\,(ps^{-1})$

$\phi_s=0.001\pm0.101 \pm0.027\,(rad)$

Ambiguity removed using interference with K^+K^- S-wave



- Combining LHCb results: $\phi_s=-0.002\pm0.083\pm0.027$ rad

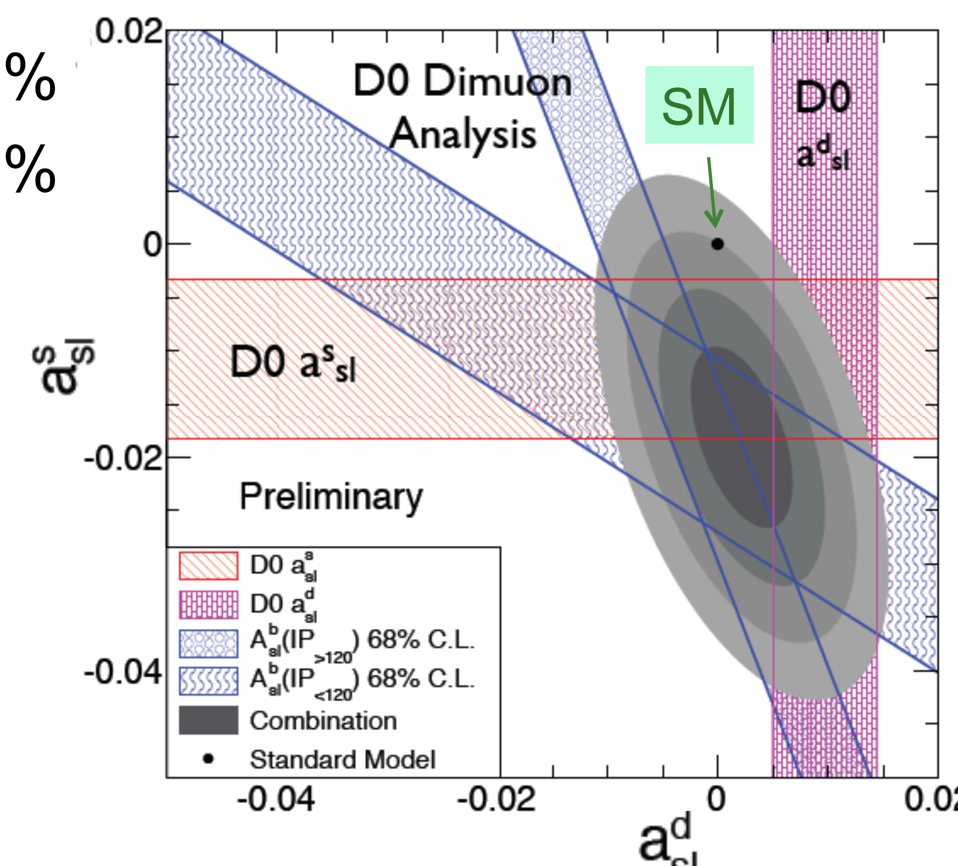
ICHEP, Melbourne, July 9, 2012

Le mélange du méson Bs (anti-b + s) avec son antiparticule, et ses désintégrations, mesurés par LHCb, s'avèrent en très bon accord avec le MS

a_{sl} according to D0

- $a^s_{sl}=(-1.81\pm0.56)\%$
- $a^d_{sl}=(-0.22\pm0.30)\%$
- 3σ from SM

(see || talk of Bertram)



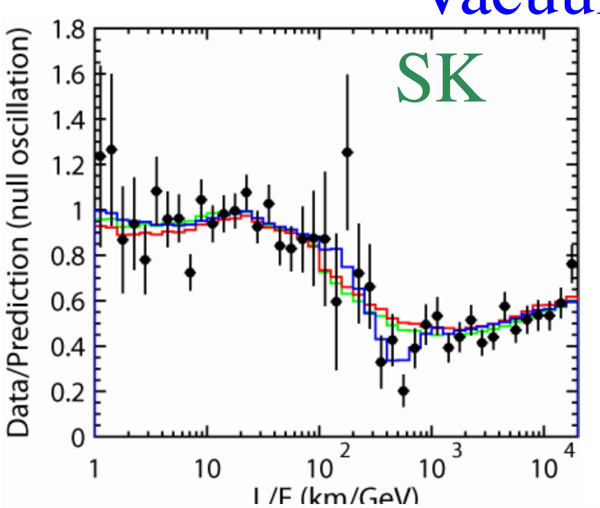
Reste une mesure de D0 (Fermilab), mais pour combien de temps ?

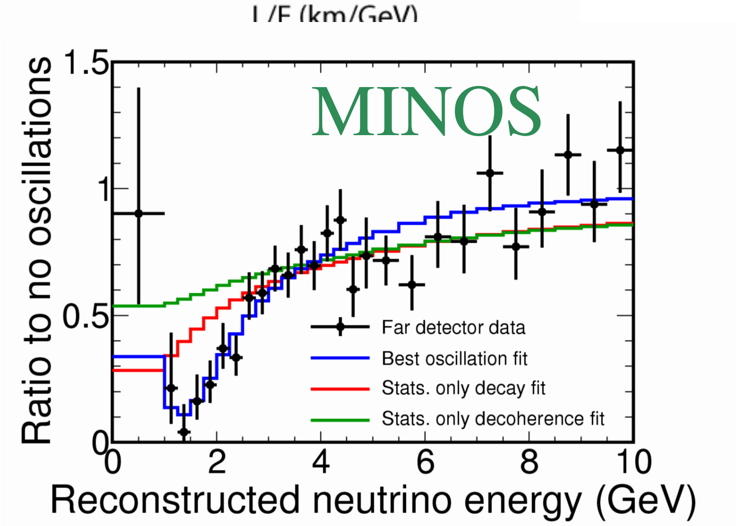
Plus vite que
leur ombre ?

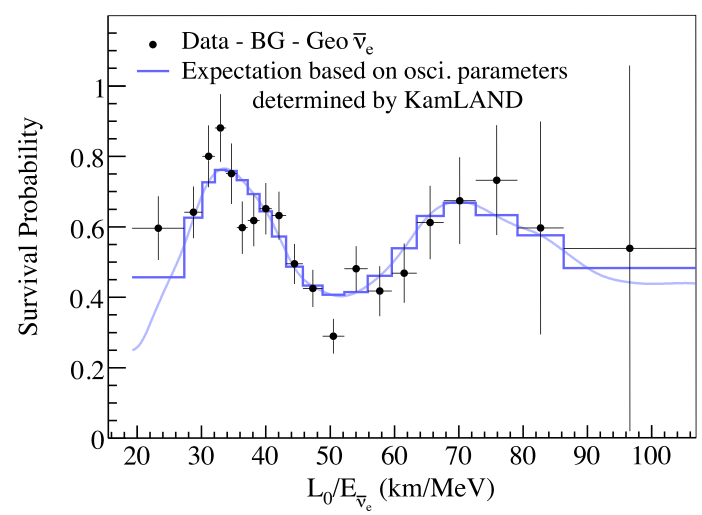
- By 2012 we have observed with high (or good) precision:
  - ∗ Atmospheric ν_μ & $\bar{\nu}_\mu$ disappear most likely to ν_τ (**SK**,MINOS)
  - ∗ Accelerator ν_μ & $\bar{\nu}_\mu$ disappear at $L \sim 250[700]$ Km (K2K,T2K, [**MINOS**])
  - ∗ Some accelerator ν_μ appear as ν_e at $L \sim 250[700]$ Km (**T2K**, [MINOS])
  - ∗ Solar ν_e convert to ν_μ/ν_τ (Cl, Ga, **SK, SNO, Borexino**)
  - ∗ Reactor $\overline{\nu_e}$ disappear at $L \sim 200$ Km (**KamLAND**)
  - ∗ Reactor $\overline{\nu_e}$ disappear at $L \sim 1$ Km (D-Chooz, **Daya-Bay, Reno**) **[NEW 2012]**

- We have confirmed:

Vacuum oscillation L/E pattern

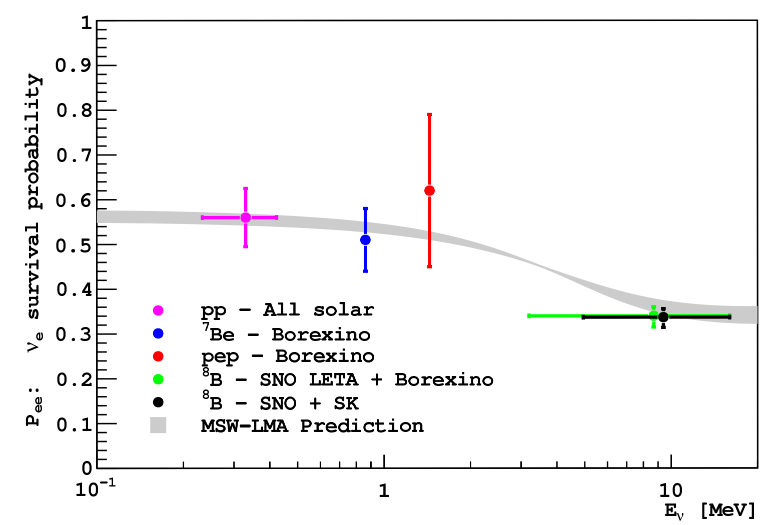






KamLAND

MSW conversion in Sun

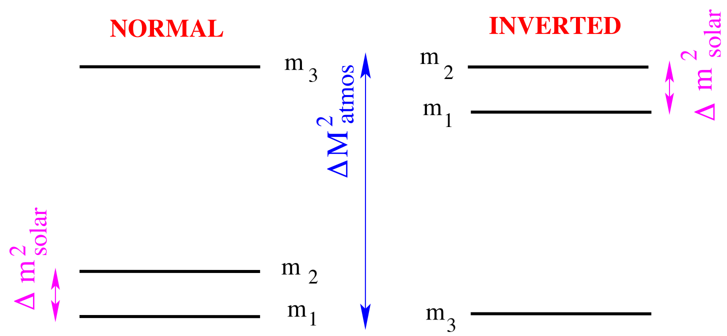


3ν Flavour Parameters

- For for 3 ν's : 3 Mixing angles + 1 Dirac Phase + 2 Majorana Phases

$$U_{\rm LEP} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13}e^{i\delta_{\rm cp}} \\ 0 & 1 & 0 \\ -s_{13}e^{-i\delta_{\rm cp}} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{21} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} e^{i\eta_1} & 0 & 0 \\ 0 & e^{i\eta_2} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

- Two Possible Orderings



Experiment	Dominant Dependence	Important Dependence
Solar Experiments	$\rightarrow \theta_{12}$	Δm^2_{21} , θ_{13}
Reactor LBL (KamLAND)	$\rightarrow \Delta m^2_{21}$	θ_{12} , θ_{13}
Reactor MBL (Daya-Bay, Reno, D-Chooz)	$\rightarrow \theta_{13}$	$\Delta m^2_{\rm atm}$
Atmospheric Experiments	$\rightarrow \theta_{23}$	$\Delta m^2_{\rm atm}$, θ_{13} ,$\delta_{\rm cp}$
Accelerator LBL ν_μ Disapp (Minos)	$\rightarrow \Delta m^2_{\rm atm}$	θ_{23}
Accelerator LBL ν_e App (Minos,T2K)	$\rightarrow \delta_{\rm cp}$	θ_{13} , θ_{23}

Flavour Parameters: Present Status

- The derived ranges for the six parameters at 1σ (3σ):

$$\Delta m^2_{21} = 7.5 \pm 0.19 \left(^{+0.59}_{-0.50}\right) \times 10^{-5}\ {\rm eV}^2 \qquad \theta_{12} = 32.4^\circ \pm 0.8^\circ \left(^{+2.5^\circ}_{-1.9^\circ}\right)$$

$$\Delta m^2_{31}({\rm N}) = 2.45^{+0.067}_{-0.071} \left(^{+0.22}_{-0.20}\right) \times 10^{-3}\ {\rm eV}^2 \qquad \theta_{23} = 40.4^\circ{}^{+0.8^\circ}_{-1.8^\circ} \left(^{+13.9^\circ}_{-4.8^\circ}\right)$$

$$|\Delta m^2_{32}|({\rm I}) = 2.43 \pm 0.068 \left(^{+0.22}_{-0.20}\right) \times 10^{-3}\ {\rm eV}^2 \qquad \theta_{13} = 8.7^\circ \pm 0.45^\circ \left(^{+1.3^\circ}_{-1.5^\circ}\right)$$

$$\delta_{\rm CP} = \begin{cases} ({\rm N})\ -48^\circ{}^{+53^\circ}_{-59^\circ} \left(^{+228^\circ}_{-132^\circ}\right) \\ ({\rm I})\ -59^\circ{}^{+49^\circ}_{-60^\circ} \left(^{+239^\circ}_{-121^\circ}\right) \end{cases}$$

$$|U|_{{\rm LEP}(3\sigma)} = \begin{pmatrix} 0.795 \rightarrow 0.841 & 0.517 \rightarrow 0.584 & 0.141 \rightarrow 0.179 \\ 0.213 \rightarrow 0.543 & 0.425 \rightarrow 0.728 & 0.575 \rightarrow 0.802 \\ 0.213 \rightarrow 0.541 & 0.411 \rightarrow 0.720 & 0.576 \rightarrow 0.802 \end{pmatrix}$$

Conclusions

- First ICHEP with the three leptonic mixing angles determined (at $\pm 3\sigma/6$)

$\Delta m^2_{21} = 7.5 \times 10^{-5}\ \text{eV}^2\ (2.4\%)$

$$\begin{array}{l} \Delta m^2_{31} = 2.45 \times 10^{-3}\ \text{eV}^2 \\ |\Delta m^2_{32}| = 2.43 \times 10^{-3}\ \text{eV}^2 \end{array} \quad (2.8\%)$$

$\sin^2\theta_{12} = 0.3\ (4\%)$ $\sin^2\theta_{23} = 0.42\ (11\%)$ $\sin^2\theta_{13} = 0.023\ (10\%)$

- Still ignore or not significantly seen

  Majorana or Dirac?

  Absolute ν mass

  CP violation in leptons?

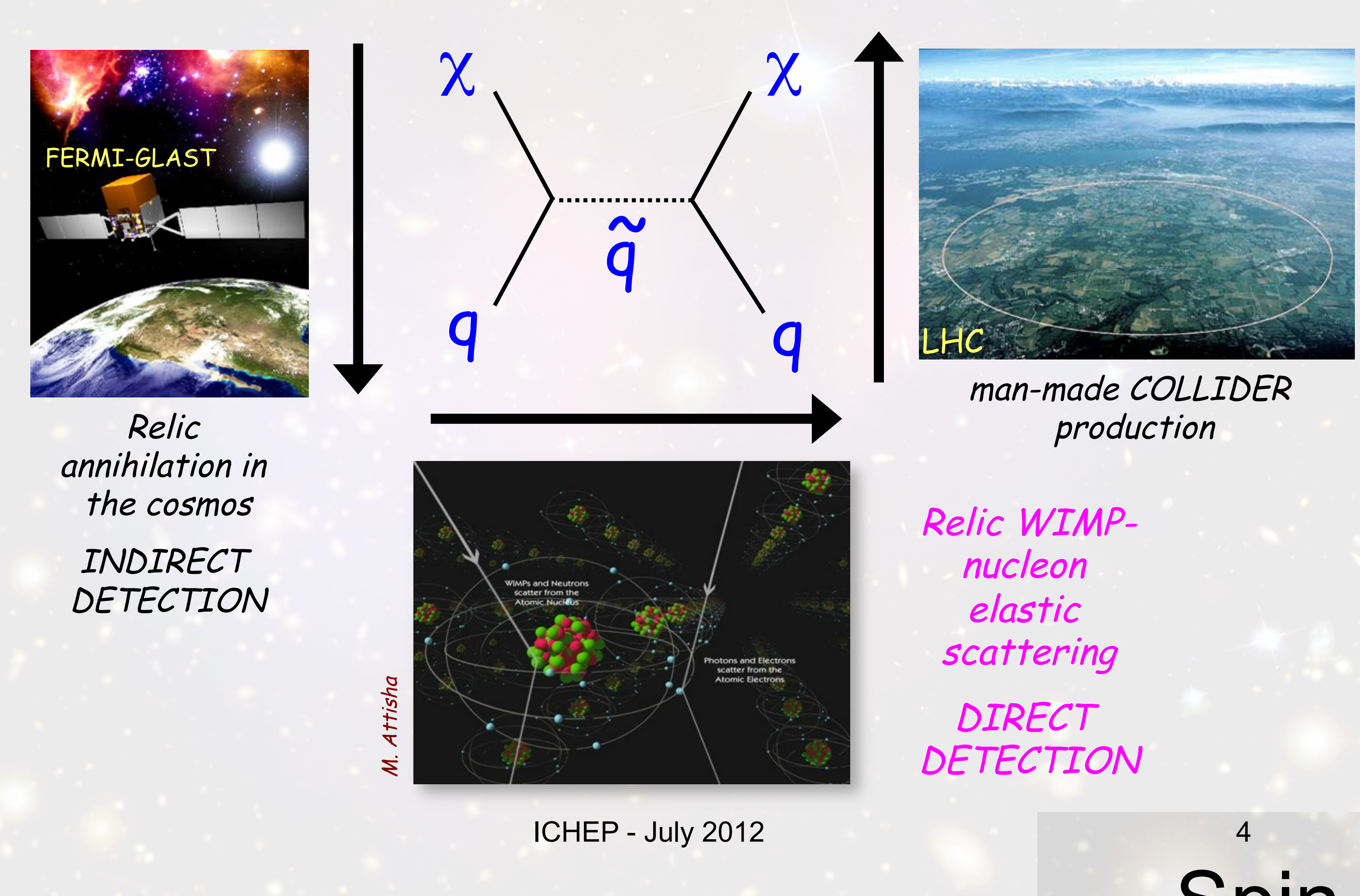
  Normal or Inverted Ordering?

  θ_{23} Octant

$\Rightarrow$ New experiments beyond approved needed to answer these questions

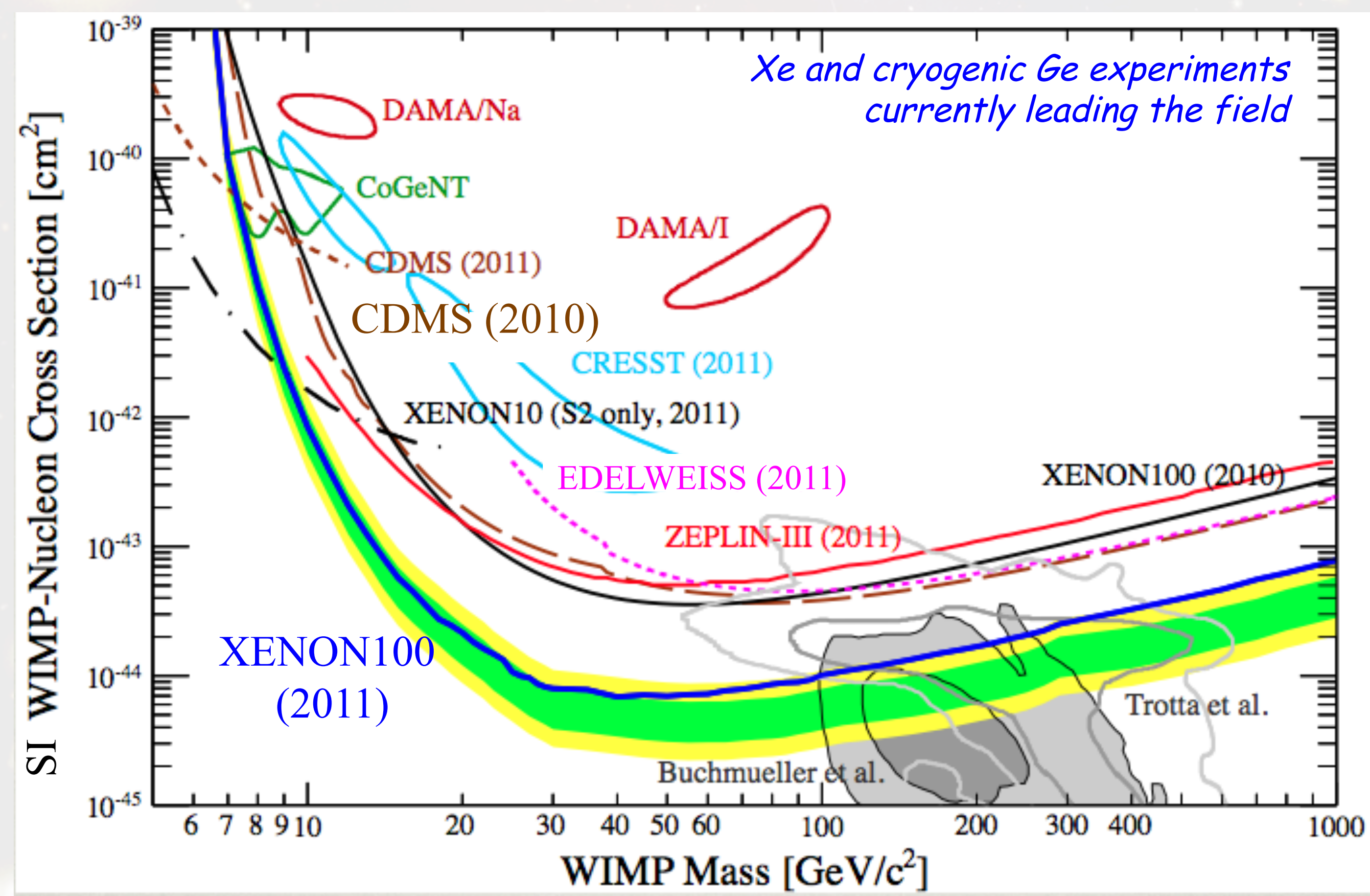
ν masses are BSM physics effects to be put together with *all other NP effects*:
from charged LFV, Collider signals, Cosmo-astroparticle…to establish
the Next Standard Model

Noir c’est noir



Beaucoup de programmes de recherche directe de matière noire par interaction sur noyaux...

Spin-Independent Landscape



Avec beaucoup de contraintes masse vs section efficace...

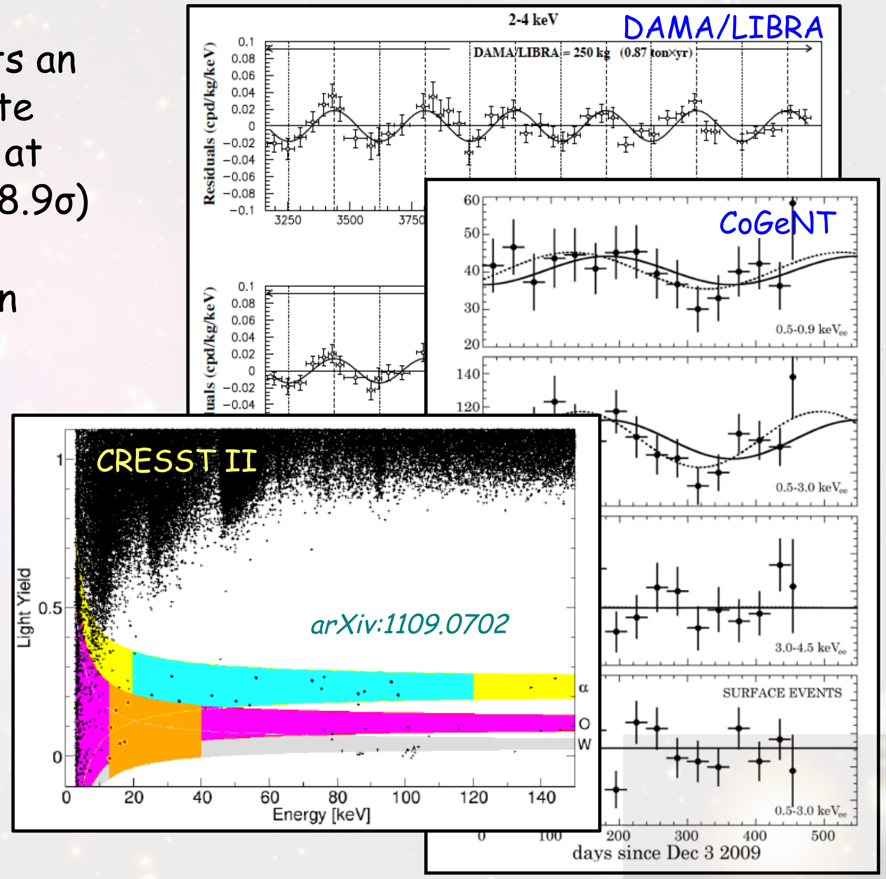
Unexplained Events

2008: DAMA/LIBRA reports an annual modulation in event rate consistent with dark matter, at high statistical significance (8.9σ)

2010/11: CoGeNT reports an overall excess of low-energy events, and an annual modulation – albeit with only ~2σ significance

2012: CRESST-II reports a 4.2σ excess of low-energy events

Bernabei et al., Eur Phys J C56 (2008)

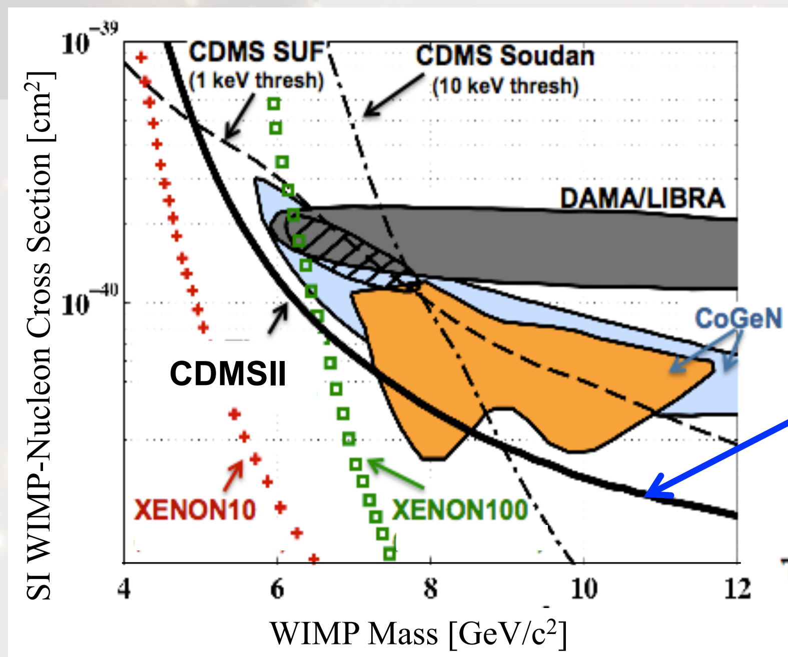


Phys. Rev. Lett. 107 (2011) 141301

ICHEP - July 2012

Quelques affirmations d'observation...

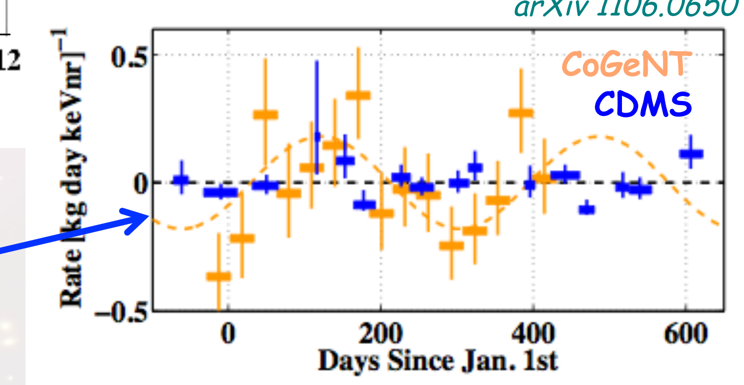
Null Observations



2011: CDMS (and XENON) extend analysis to lower thresholds by allowing more background.

Set conservative upper limits w/o bg subtraction....

arXiv 1106.0650



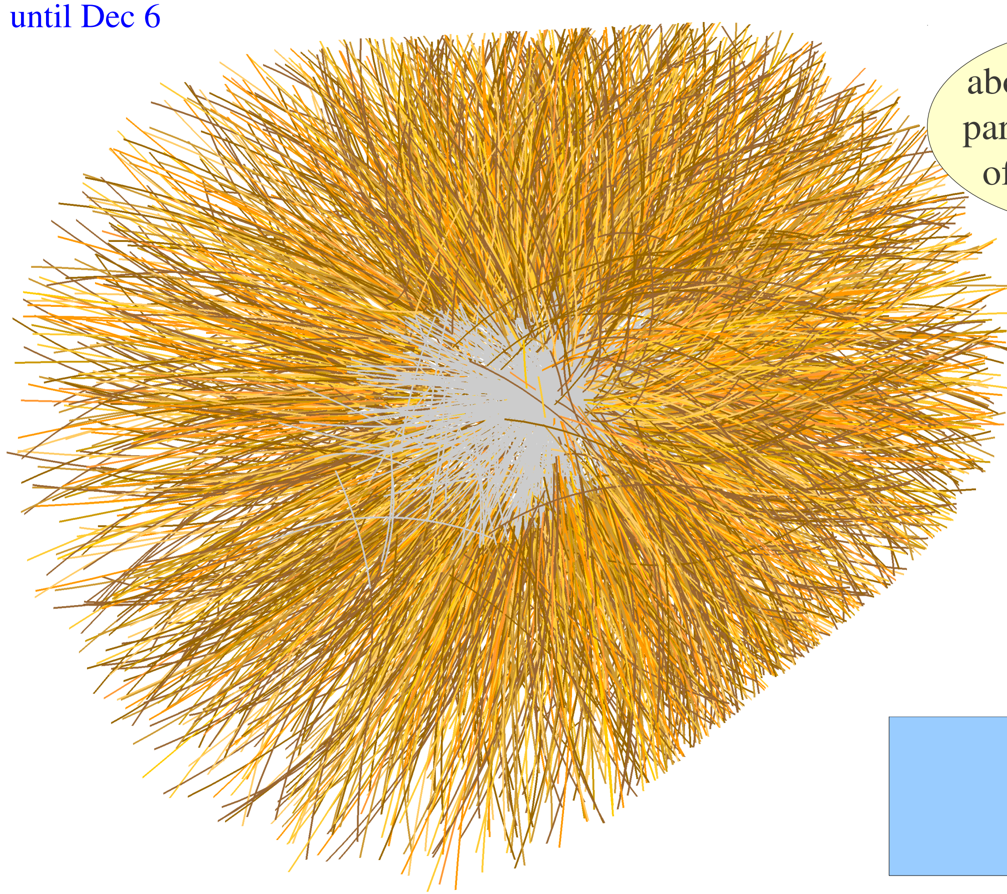
2012: CDMS looked for an annual modulation of low energy recoils and didn't see any

... pour l'instant non confirmées par les autres expériences.

Il y a aussi du plomb au LHC...

first PbPb collisions at LHC at $\sqrt{s}$ = 2.76 A TeV

setup for ion collisions: November 4, 2010
first collisions with stable beams:
November 8 until Dec 6



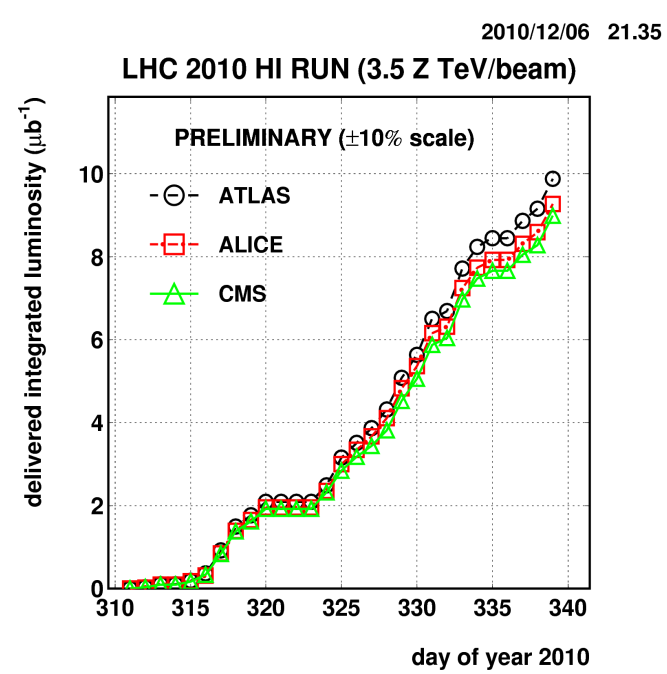
about 3000 charged particles in 1.8 units of pseudorapidity

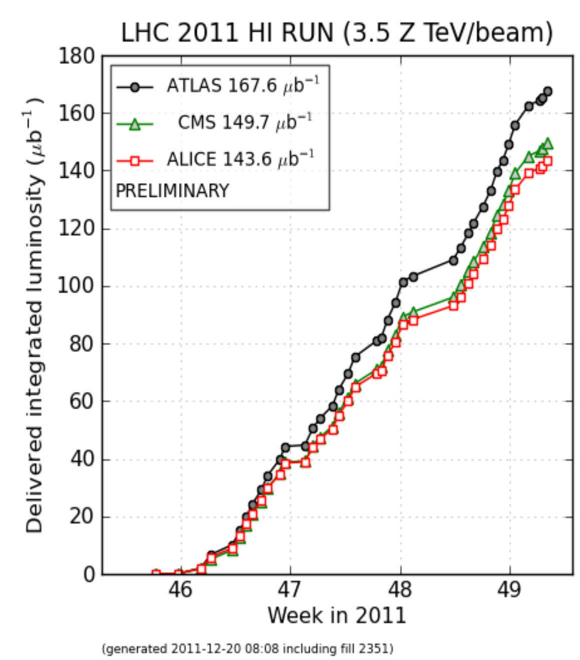
L'expérience ALICE a commencé à prendre des données Pb+Pb...

Heavy Ion Running at the LHC

2 good Pb+Pb runs in 2010 and 2011,
2011 already exceeding design luminosity for 3 experiments and this beam energy

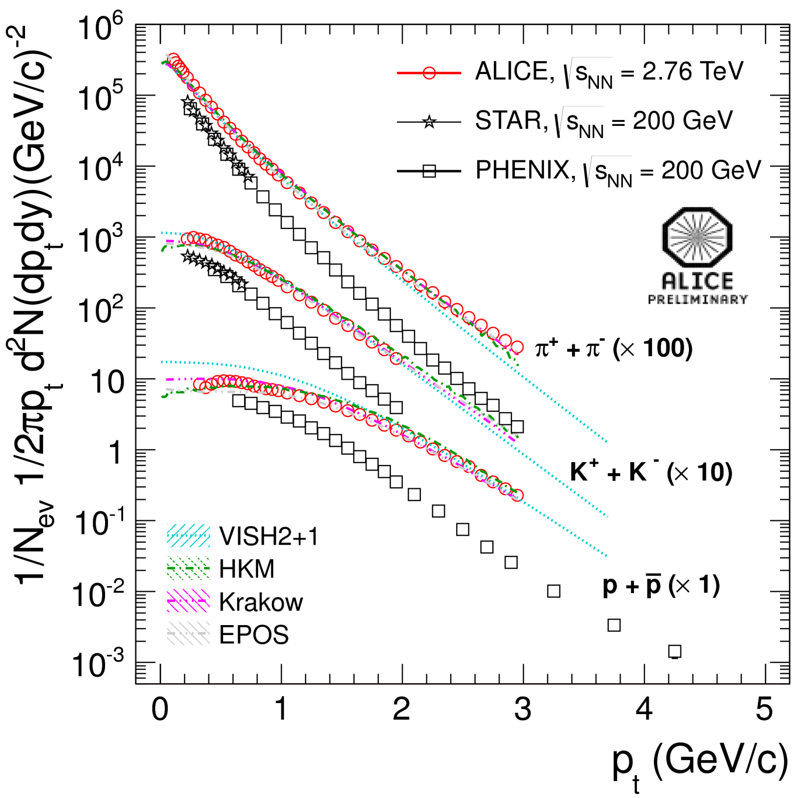
... pour identifier les caractéristiques du plasma de quarks et de gluons qui devrait y être formé





Jan/Feb 2013: p + Pb run

Spectra of Identified Hadrons

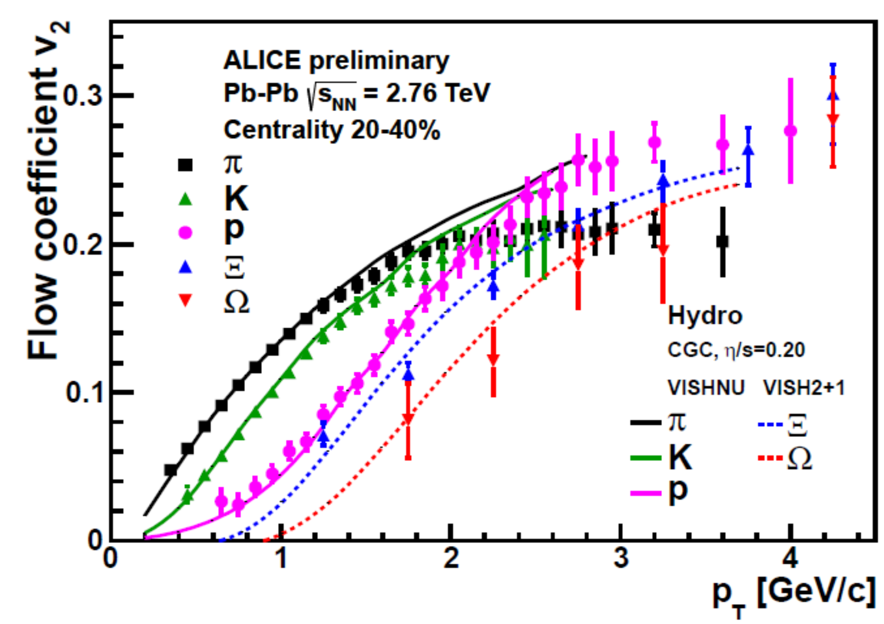


ALI-PREL-27004

- spectral shapes strongly mass dependent - characteristic for hydrodynamic expansion
- indicate significantly larger expansion velocity than at RHIC
- hydro calculations that reproduce HBT are also describing spectra very well (HKM, Krakow)

Pour le moment, des modèles hydrodynamiques simples du QGP reproduisent bien la production des diverses particules observées (quantité, répartition spatiale)

Elliptic Flow in PbPb Collisions at $\sqrt{s_{NN}}$ = 2.76 TeV



Pour le reste (en particulier une preuve du déconfinement), la situation reste encore assez confuse...

rapidly rising v_2 with p_t and mass ordering typical features of hydrodyn. expansion
same hydrodynamics calc. with small eta/s reproduces data

A l’année prochaine,
pour Lepton Photon 2013 à Stanford (USA)
EPS-HEP 2013 à Stockholm (Suède)

ou dans deux ans, pour ICHEP 2014,
à Valence (Espagne) !