Highlights of Moriond EWK 2013

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Atlas/theory lunch seminar, March 21,2013

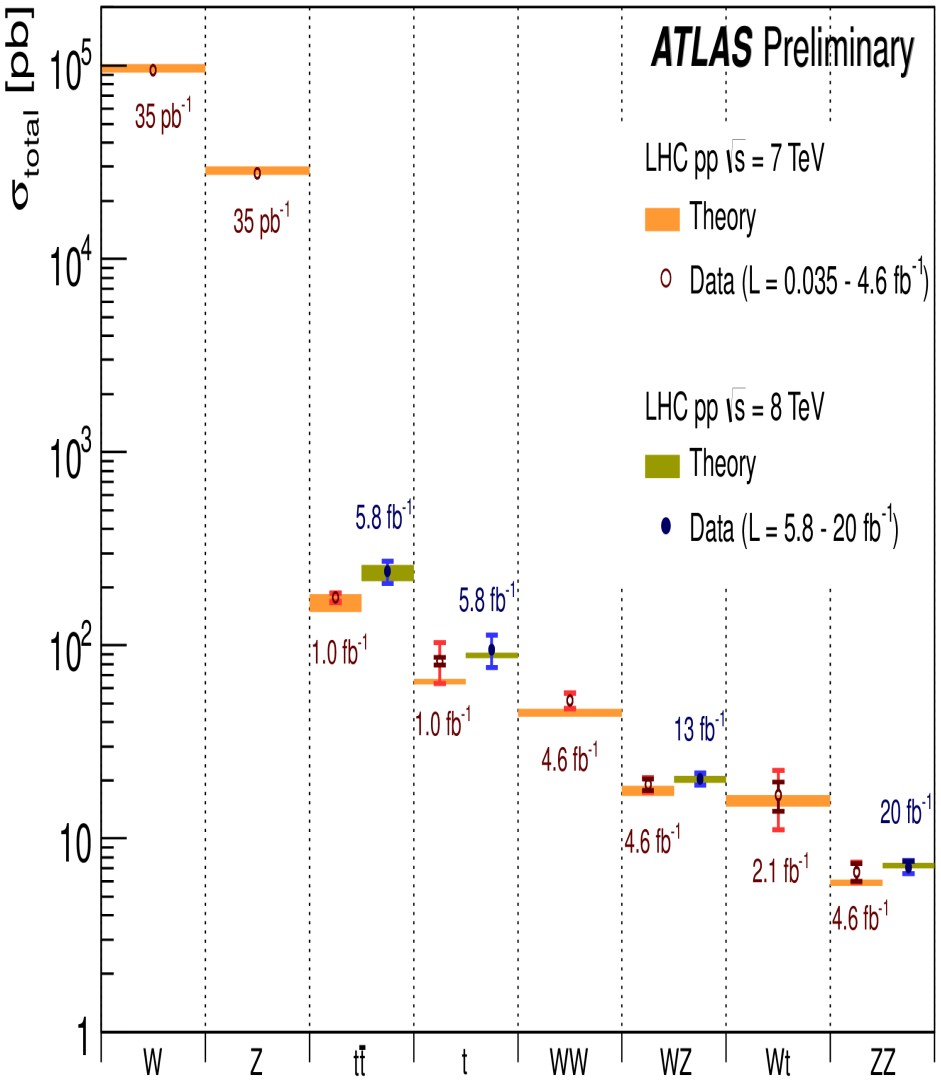
Outline

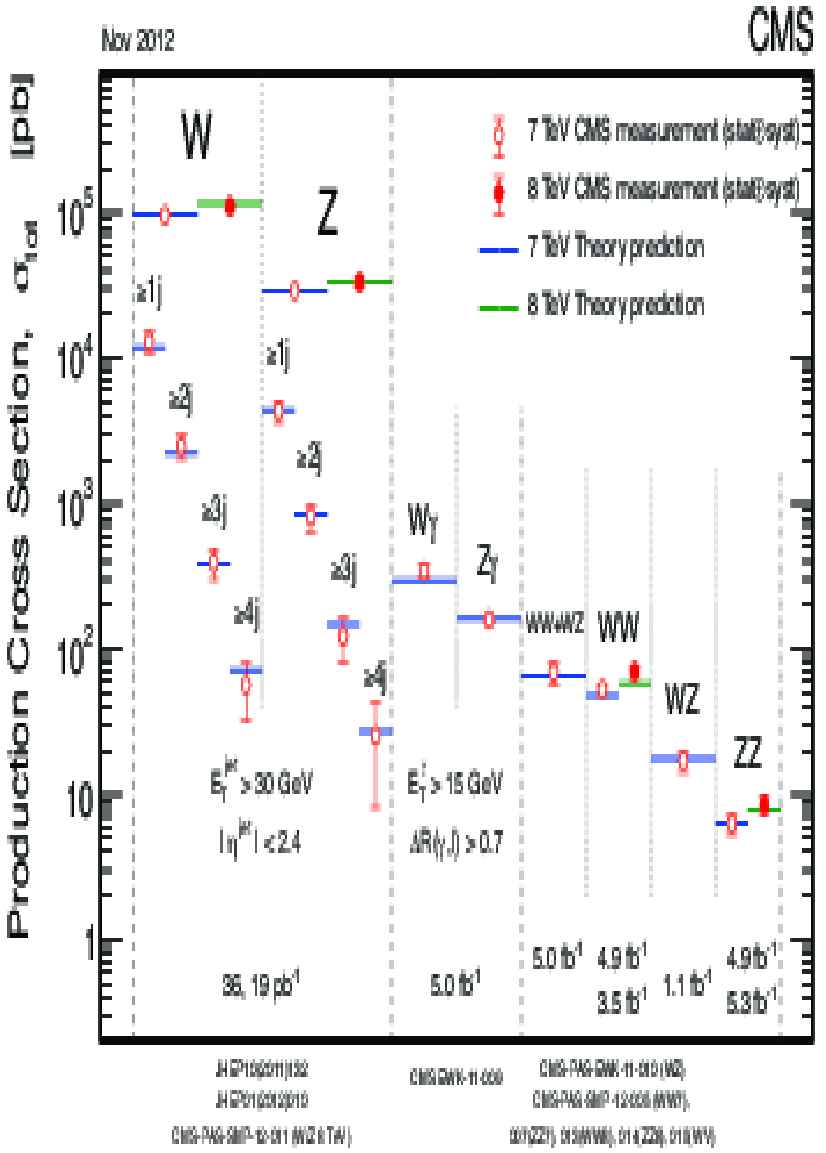
- There are many interesting results reported at Moriond EWK. It would not be possible to summarize them all in 30 mintues.
- All the talks can be found at https://indico.in2p3.fr/conferenceProgram.py?confid=7411 (EWK) and moriond.in2p3.fr/QCD/2013/MorQCD13Prog.html (QCD)
- The summary of expeimental talks by Paris contains 98 pages !
- I will focus on some new results reported at the conference.
- All the errors are mine.

Executive Summary

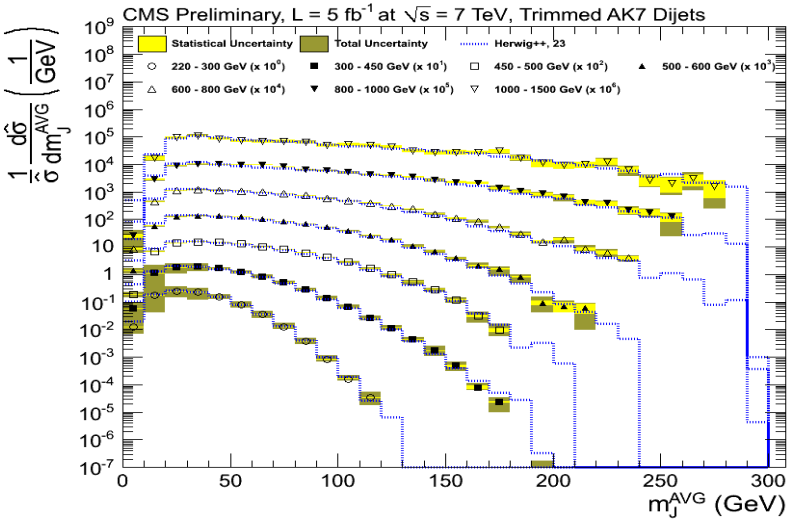
- The talks are evenly distribued between experiments ,theory, and among topics: Heavy Flavor, Top, Dark Sector, Neutrinos, Cosmos, SM Scalar, SUSY, and BSM.
- So far, there is no sign of new physics
  - –All discrepancies of the past are either gone or getting close to SM predictions (W+jj, $B \rightarrow \tau\upsilon$, ΔA_{CP} in D^0, top A_{FB})
  - –The new boson is now called the Higgs boson.
  - –No signs of SUSY
  - –No signs of any new physics
- However, reasons for the physics BSM are still remaining:
  - –Dark energy, dark matter, baryon asymmetry, mass of neutrino, and naturalness of the EWSB scale.

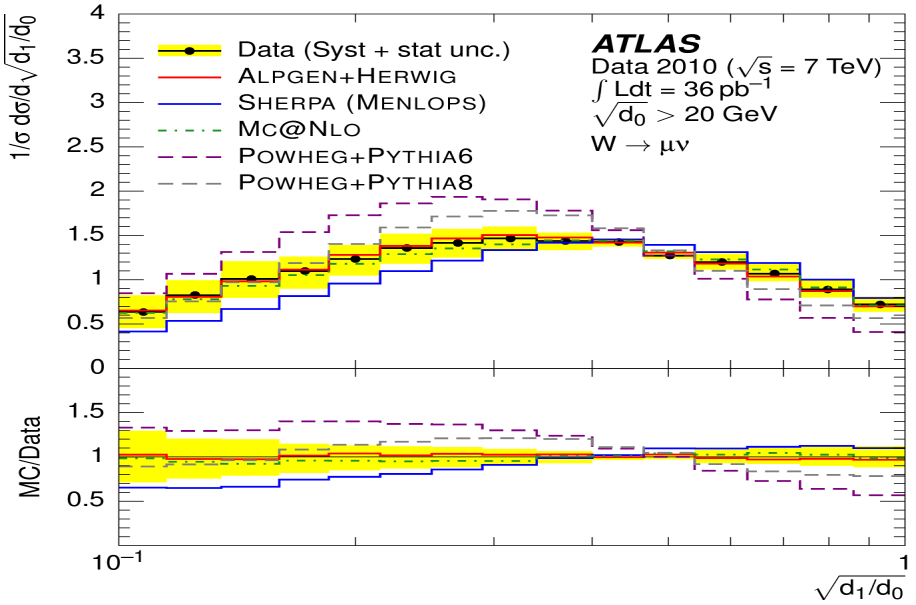
reDiscover SM @ LHC

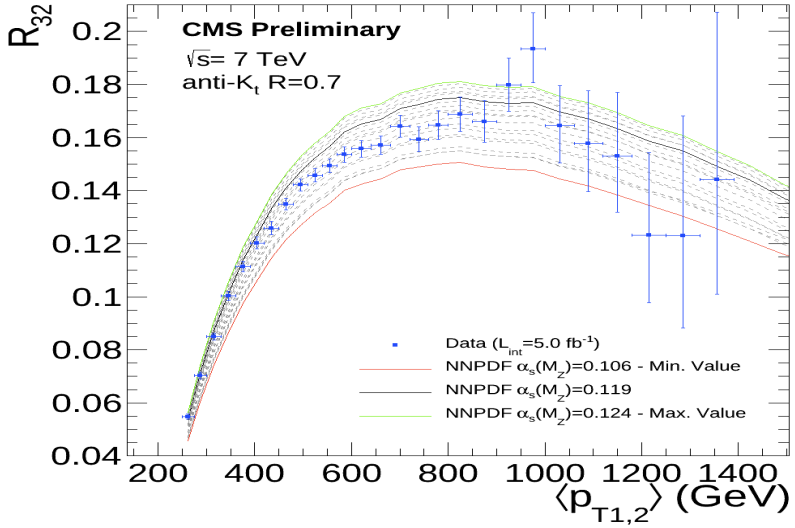


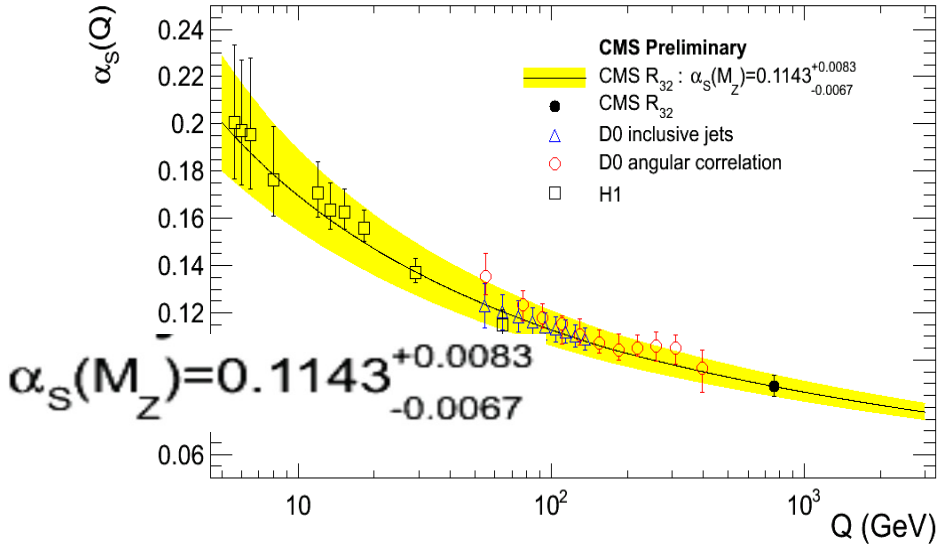


QCD at work @ LHC

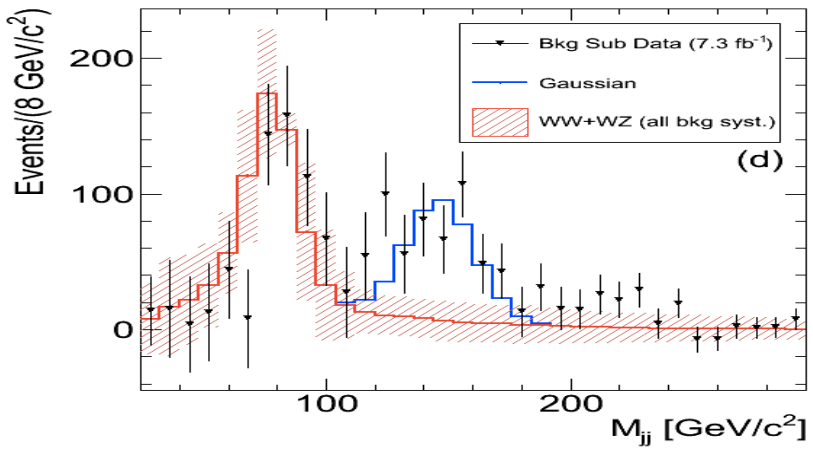


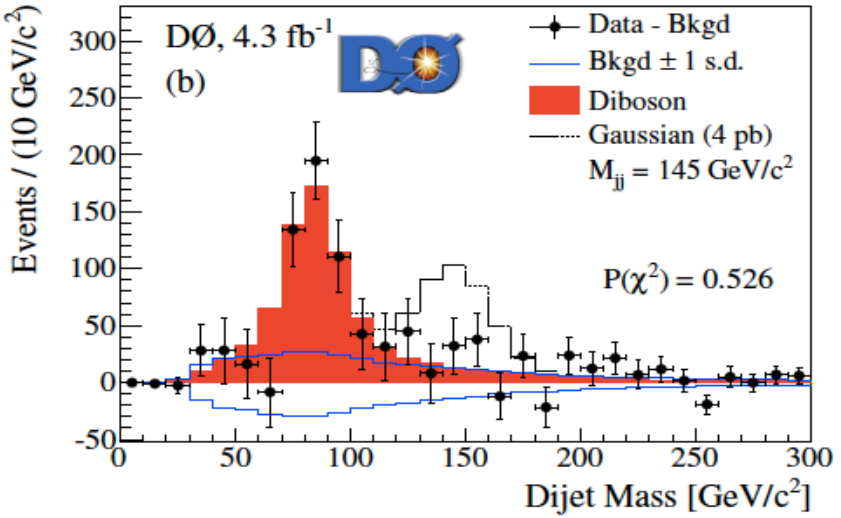


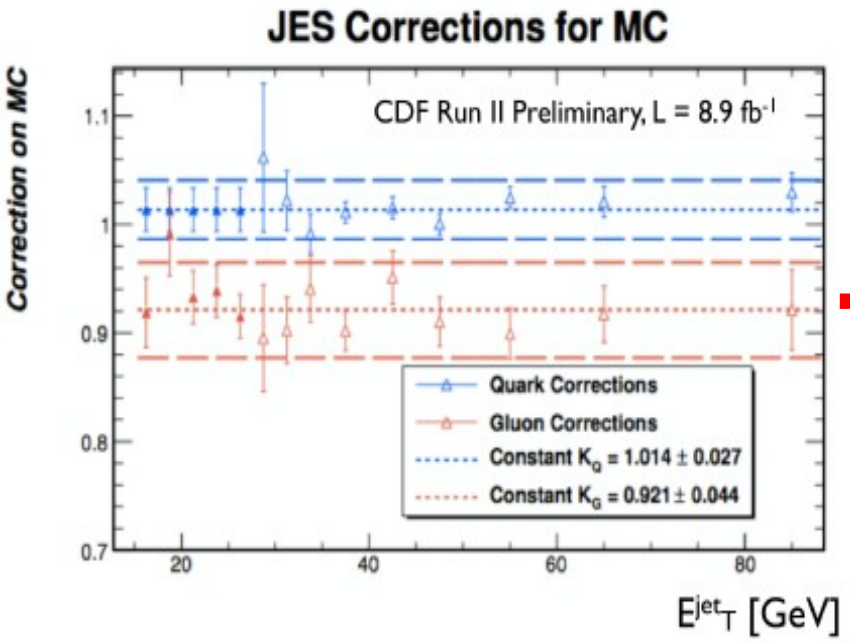


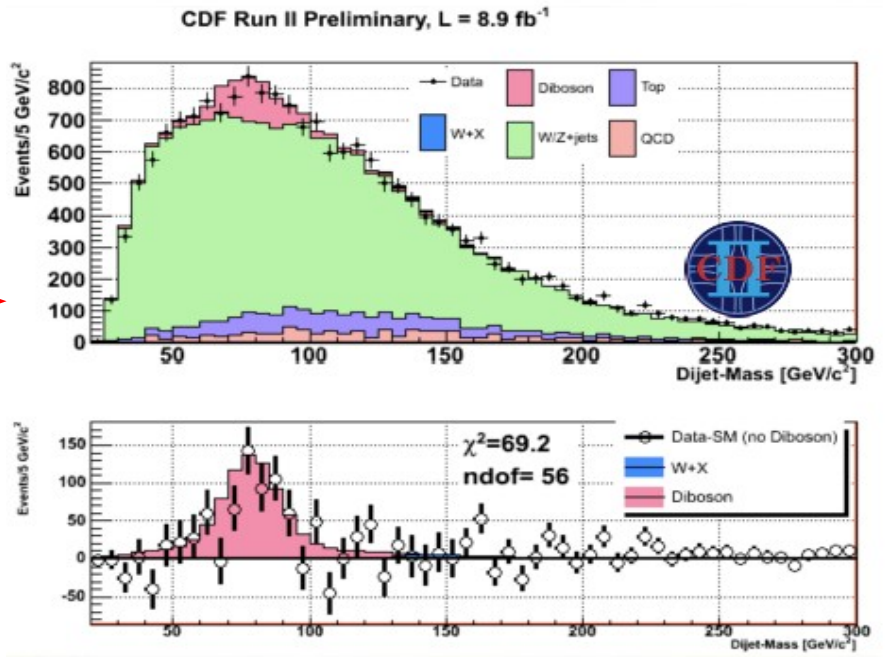


The W+jj Bump Hunting (CDF)



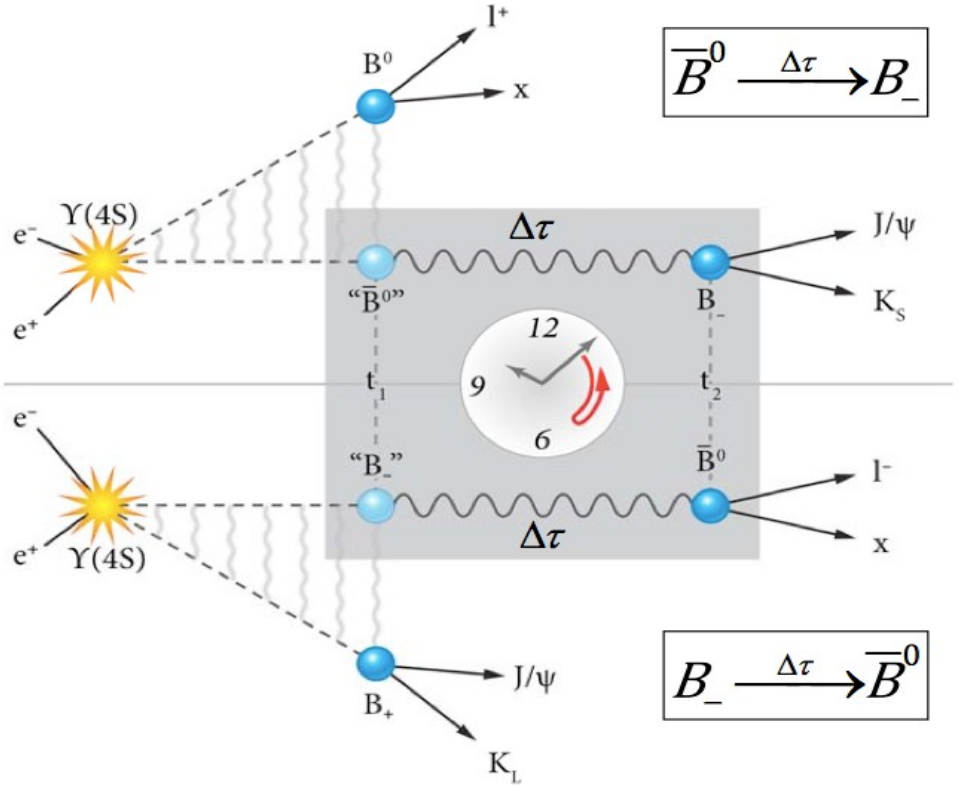






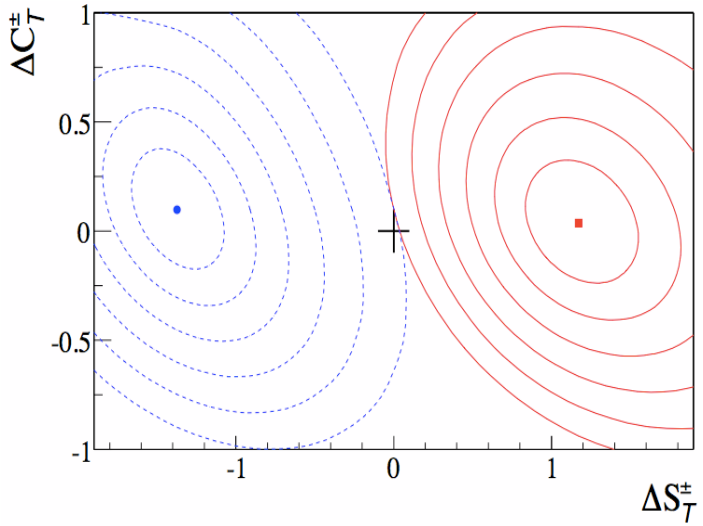
T violation (BaBar)

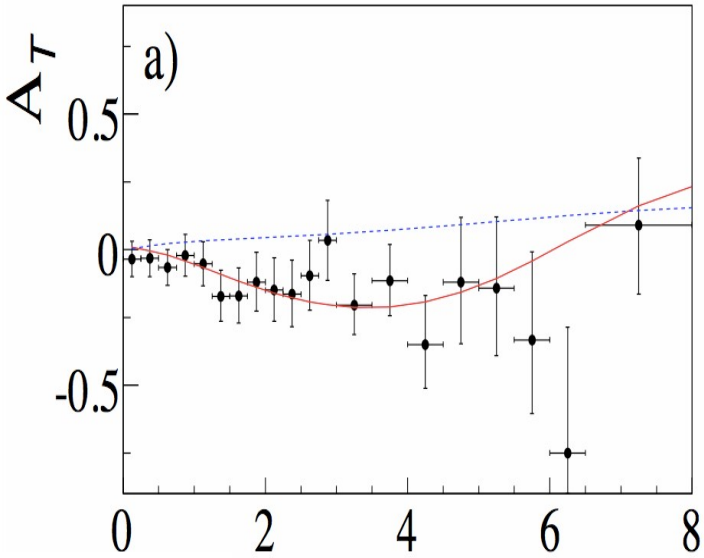
- First T-violation in B decays, this is direct by comparing the rates B0->B_ and B_ ->B0
- It's 14 sigma significance.



$\overline{B}^0 \xrightarrow{\Delta\tau} B_-$

$B_- \xrightarrow{\Delta\tau} \overline{B}^0$

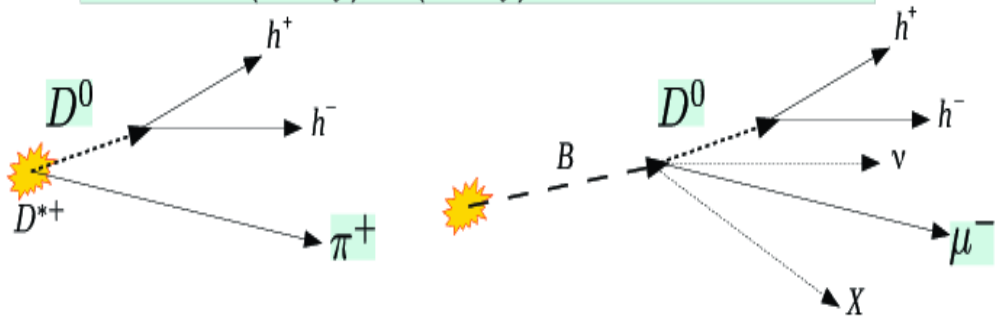


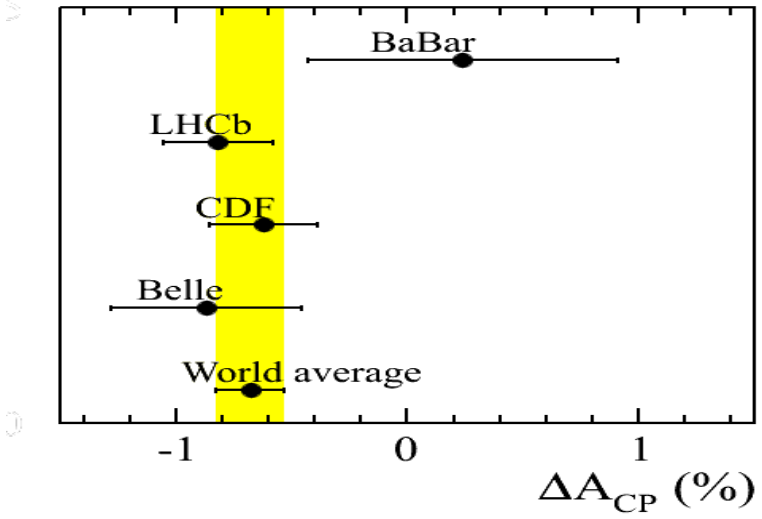


$$g^{\pm}_{\alpha,\beta}(\Delta\tau) \propto e^{-\Gamma\Delta\tau}\{1 + S^{\pm}_{\alpha,\beta}\sin(\Delta m_d \Delta\tau) + C^{\pm}_{\alpha,\beta}\cos(\Delta m_d \Delta\tau)\}$$

ΔA_{CP} in $D^0 \to hh$ (LHCb)

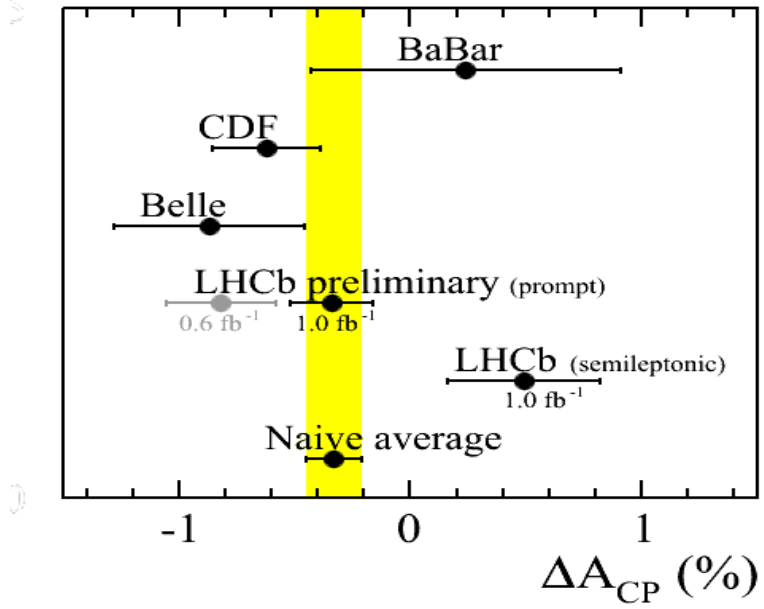
$$A(f) = \frac{N(D^0 \to f) - N(\bar{D}^0 \to f)}{N(D^0 \to f) + N(\bar{D}^0 \to f)}, \quad f = K^+K^-, \pi^+\pi^-$$





Semileptonic: $\Delta A_{CP} = (+0.49 \pm 0.30(stat.) \pm 0.14(syst.))\ \%$

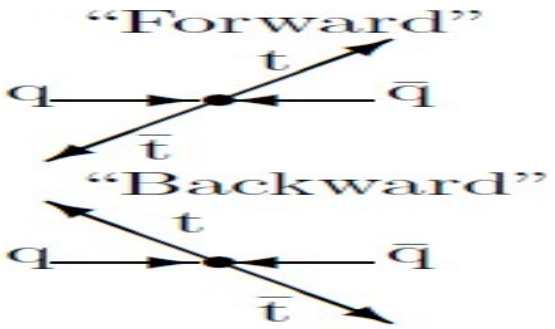
Prompt: (preliminary) $\Delta A_{CP} = (-0.34 \pm 0.15(stat.) \pm 0.10(syst.))\ \%$



- The two measurement are compatible at the 3 % level
  - $\chi 2 = 4.85$
- Naive average (neglecting indirect CP violation)

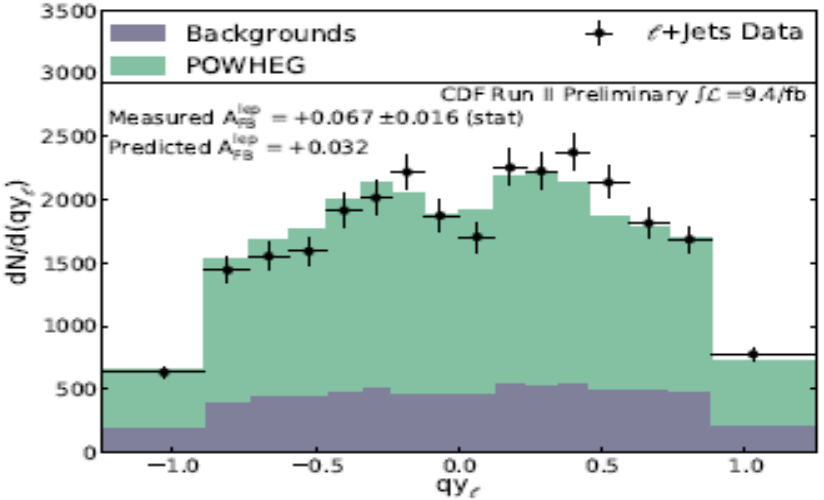
$$\Delta A_{CP,LHCb} = (-0.15 \pm 0.16)\ \%$$

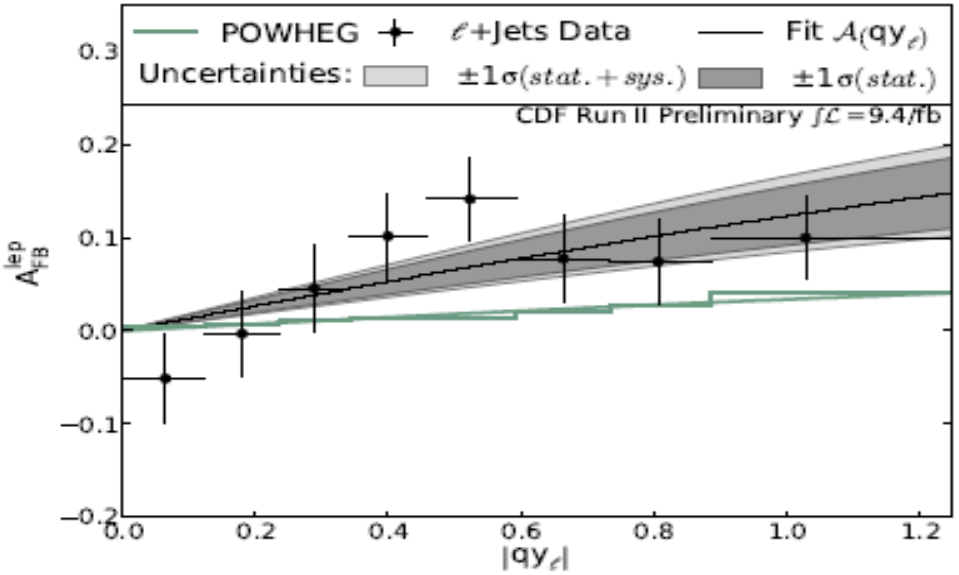
Top Forward-backward Asymmetry(CDF)



$$A_{FB}^{\ell} = \frac{N(q_\ell \eta_\ell > 0) - N(q_\ell \eta_\ell > 0)}{N(q_\ell \eta_\ell > 0) + N(q_\ell \eta_\ell > 0)}$$

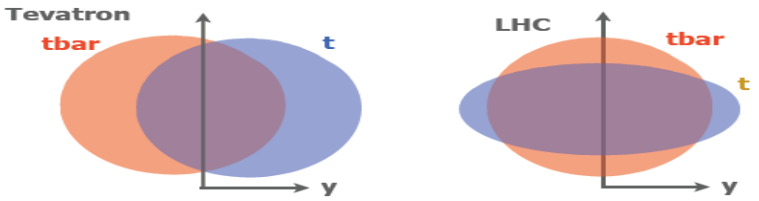
- After correcting for acceptance and extrapolating: $A_{FB}^{l} = \left(9.4 \pm 2.4(\text{stat.})^{+2.2}_{-1.7}(\text{syst.})\right)\%$ compared to QCD+EW prediction of 3.6%
- Deviation of $\sim 2\sigma$





Forward-background Asymmetry at LHC

- At LHC qqbar→ttbar, tops tend to be "more forward" than anti-tops.



Reconstructing $t\bar{t}$: $\Delta|y| = |y_t| - |y_{\bar{t}}|$

$$A_C = \frac{N(\Delta|y|>0) - N(\Delta|y|<0)}{N(\Delta|y|>0) + N(\Delta|y|<0)}$$

In dilepton decays can also use: $\Delta|\eta| = |\eta_{l+}| - |\eta_{l-}|$

$$A^{ll}{}_C = \frac{N(\Delta|\eta|>0) - N(\Delta|\eta|<0)}{N(\Delta|\eta|>0) + N(\Delta|\eta|<0)}$$

semi leptonic decay results

ATLAS [Eur. Phys. J. C72 (2012) 2039]: $A_C = -0.019 \pm 0.028_{(stat)} \pm 0.024_{(syst)}$

CMS [Phys. Lett. B717 (2012) 129]: $A_C = 0.004 \pm 0.010_{(stat)} \pm 0.011_{(syst)}$

A_C^{theory} (7TeV)= 0.0115 ± 0.0006

J.H. Kuhn and G. Rodrigo
JHEP 1201 (2012)

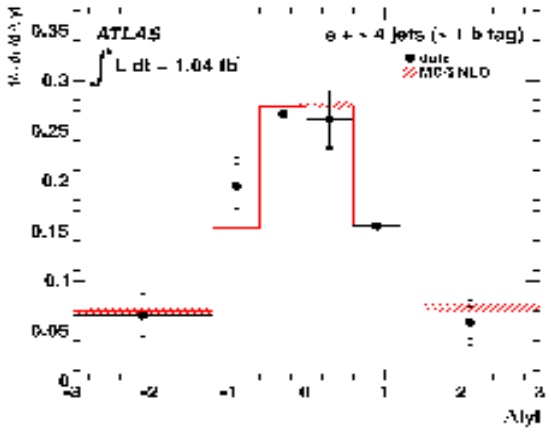
dileptonic decay results

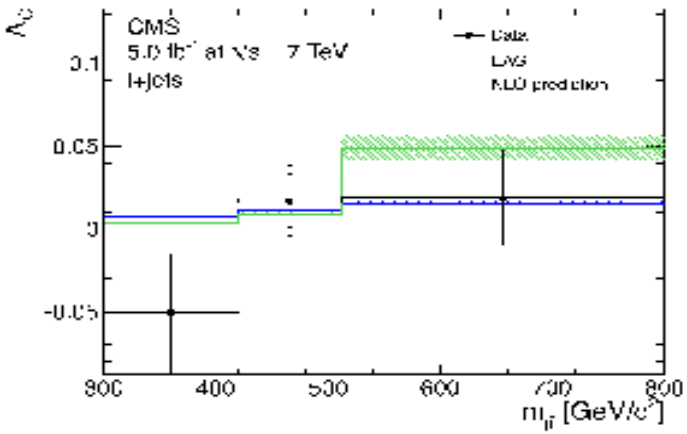
ATLAS [ATLAS-CONF-2012-057]: $A_C = 0.057 \pm 0.024_{(stat)} \pm 0.015_{(syst)}$ $\quad A^{ll}{}_C = 0.023 \pm 0.012_{(stat)} \pm 0.008_{(syst)}$

CMS [CMS PAS TOP-12-010]: $A_C = 0.050 + 0.043_{(stat)} + {}^{0.010}_{0.009(syst)}$ $\quad A^{ll}{}_C = 0.010 + 0.015_{(stat)} + 0.006_{(syst)}$

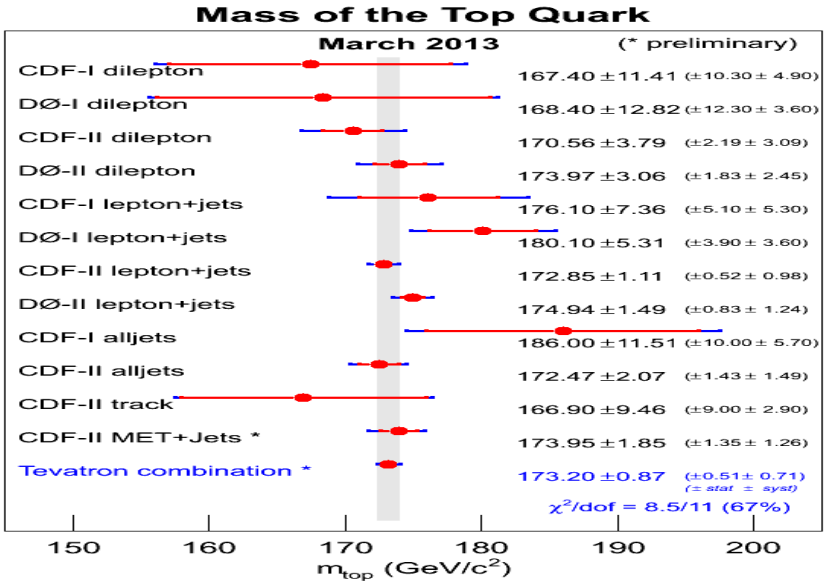
ATLAS Combined [ATLAS-CONF-2012-057]:

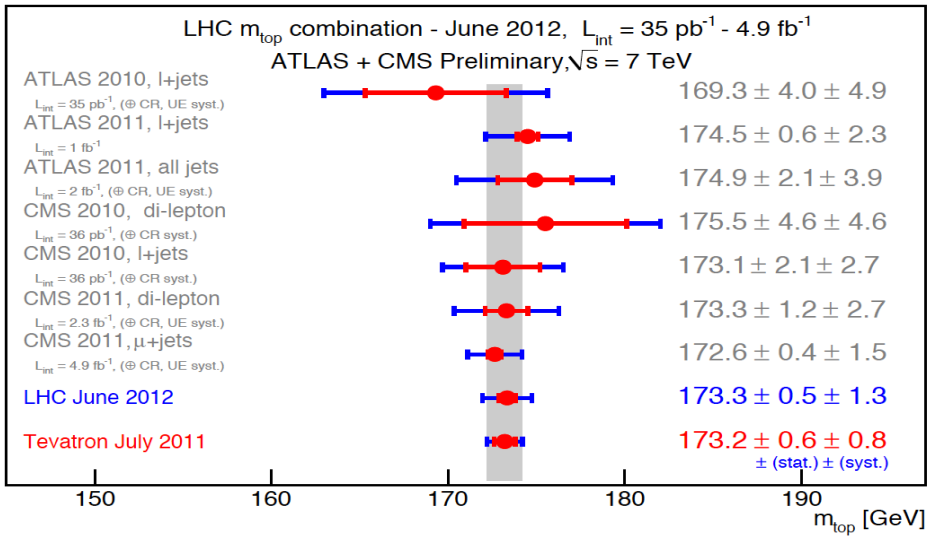
$A_C = 0.029 \pm 0.018_{(stat)} \pm 0.014_{(syst)}$

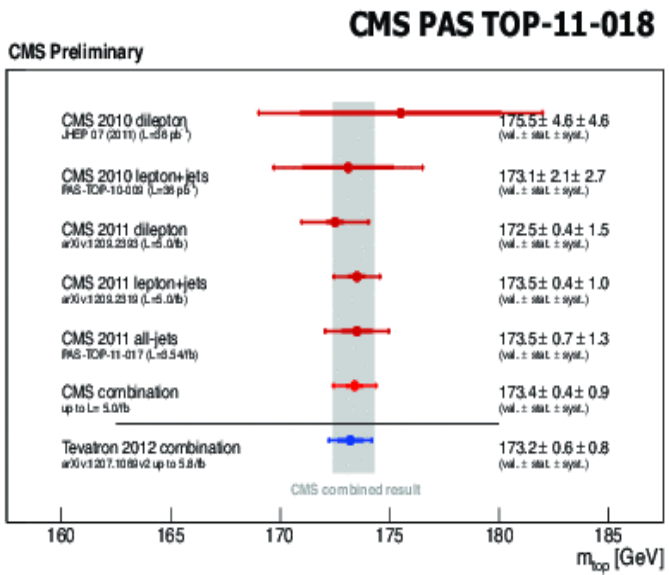




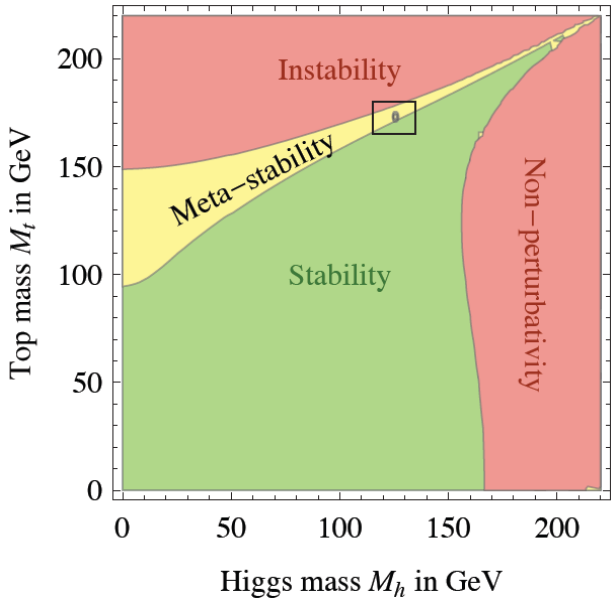
Top Mass and its Implication

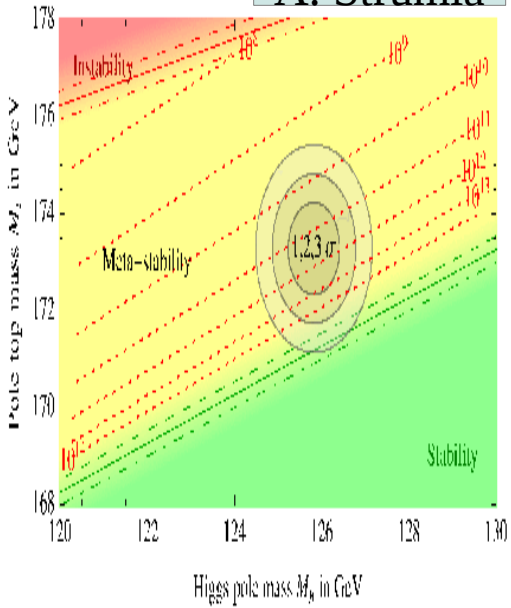






A. Strumia





T2K Results

- Data: from Jan 2010 to July 2012

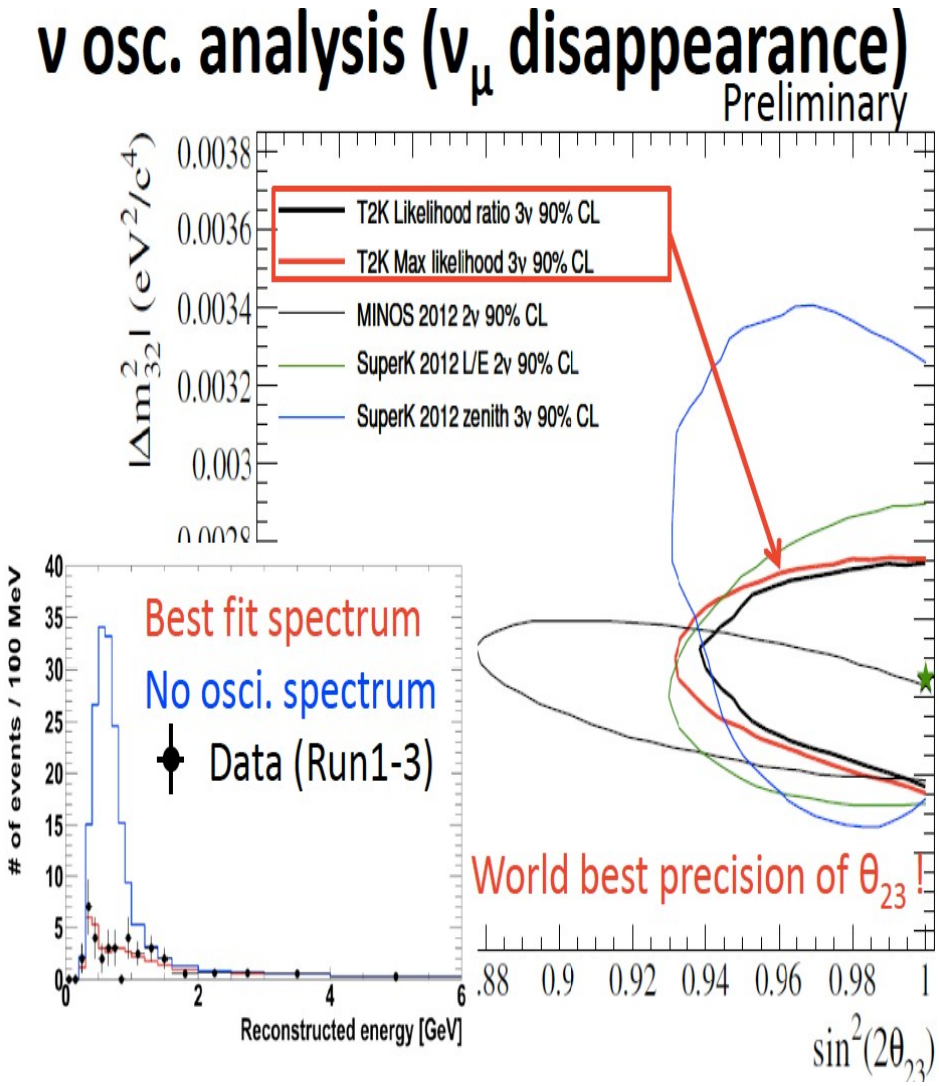
  3.01×10^{20} Protons On Target (POT)

  ~4% of T2K's target POT (7.8×10^{21}POT)

  Stable ν beam in whole period.

- Oscillation analysis results
  - Near detector measurement
  - **ν_μ disappearance : θ_{23}&Δm_{32}**
    (New results in this winter)
  - ν_e appearance: θ_{13} (shown in ICHEP 2012)

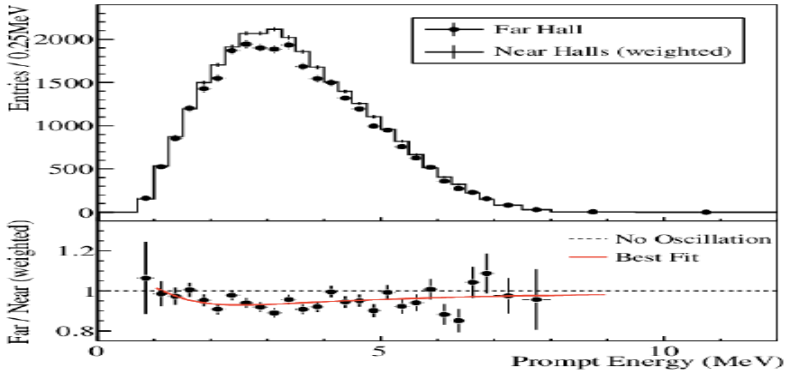
Error on # of event@SK	w/ ND280 Meas.	w/oND280 Meas.
Flux × ν x-sec.	21.7%	4.2%
Un-corr ν x-sec	6.2%	
SK detector	10.5%	
Final State Int.	3.5%	
Total	25.3%	13.5%

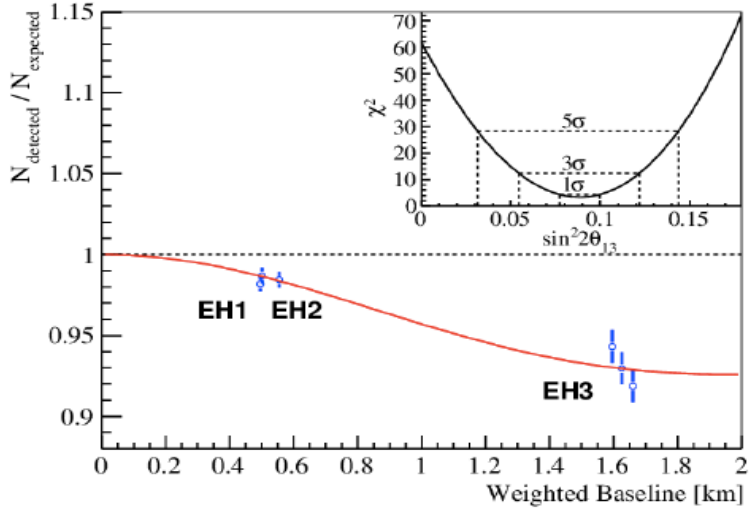


- $(\sin^2 2\theta_{23}, \Delta m^2_{23}) = (1.00\text{-}0.068,\ 2.45 \pm 0.30 \times 10^{-3}\ \text{eV}^2)$ @90% CL

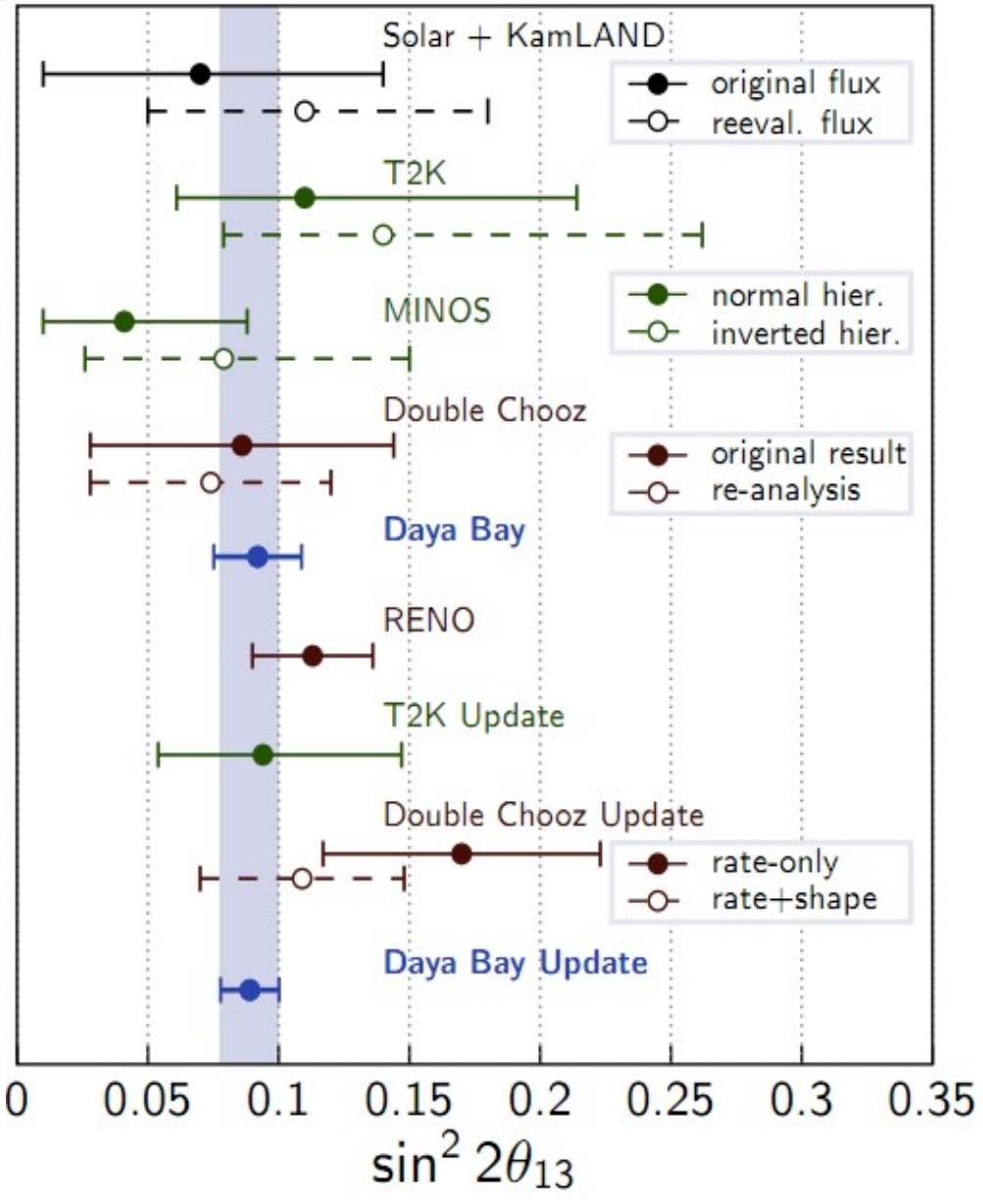
θ_{13} (Daya Bay)

- Update using data up to May 2012.

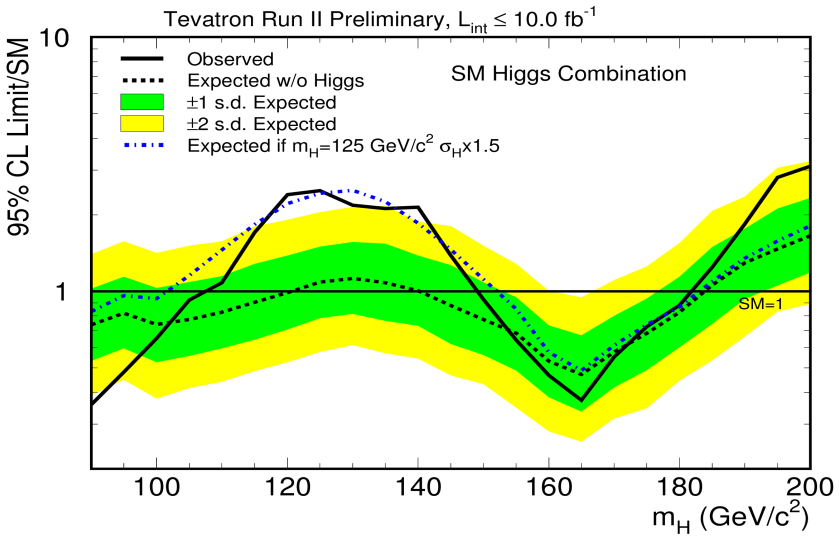


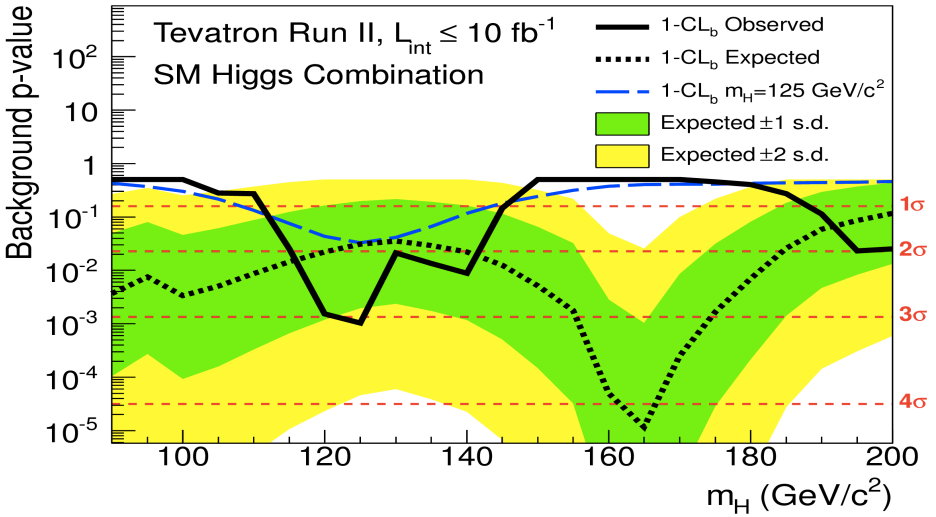


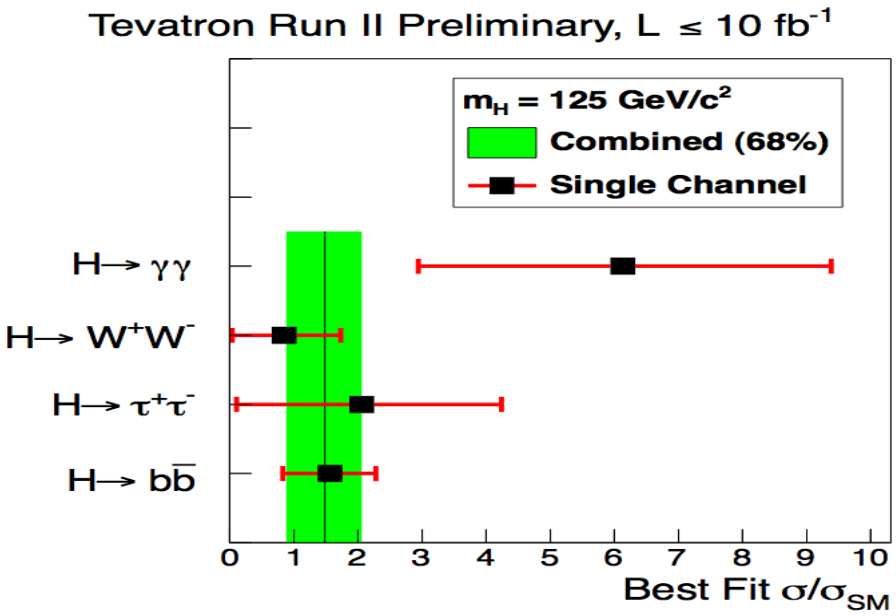
$$\sin^2 2\theta_{13} = 0.089 \pm 0.010(\text{stat}) \pm 0.005(\text{syst})$$

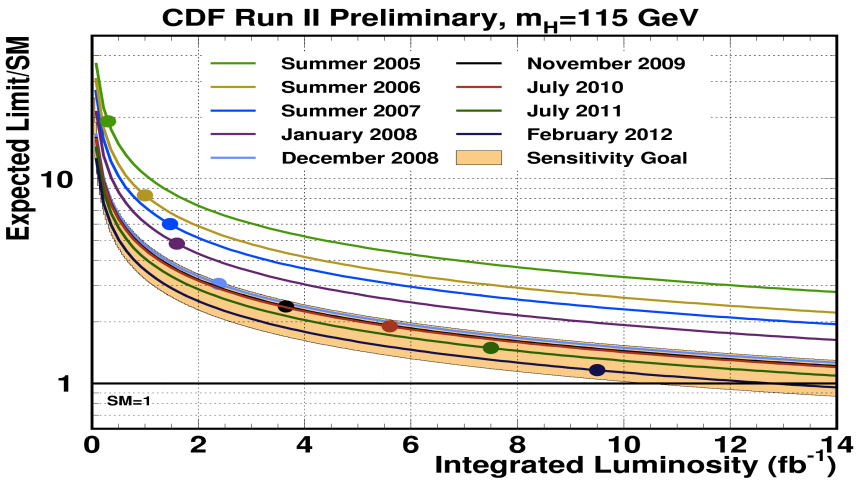


Tevatron Higgs Searches

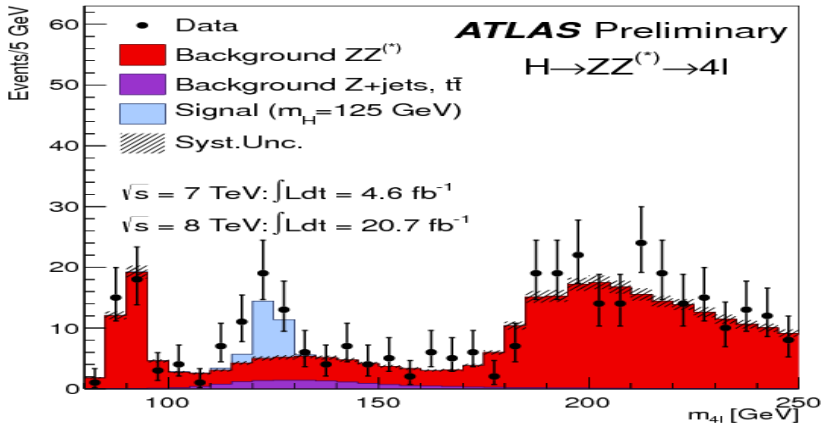


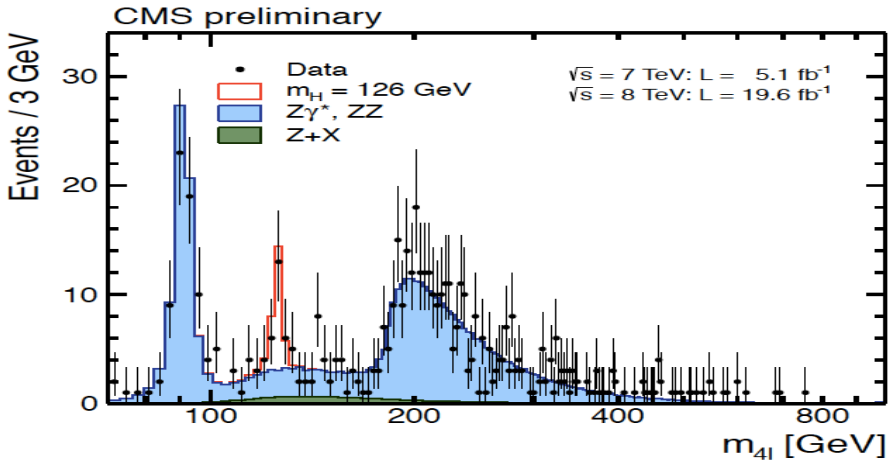


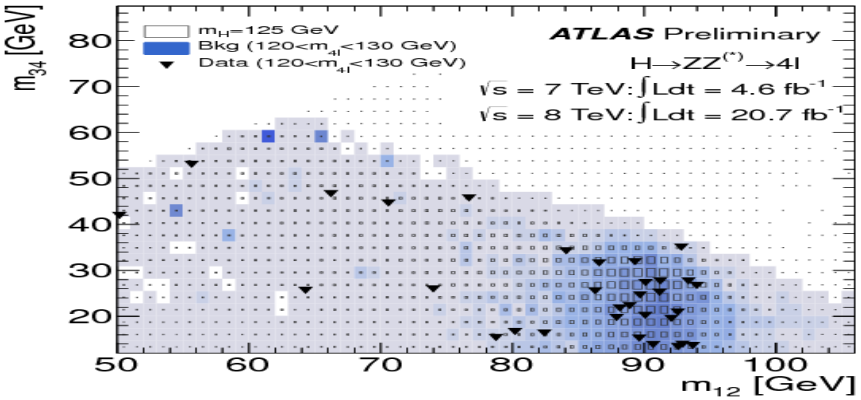


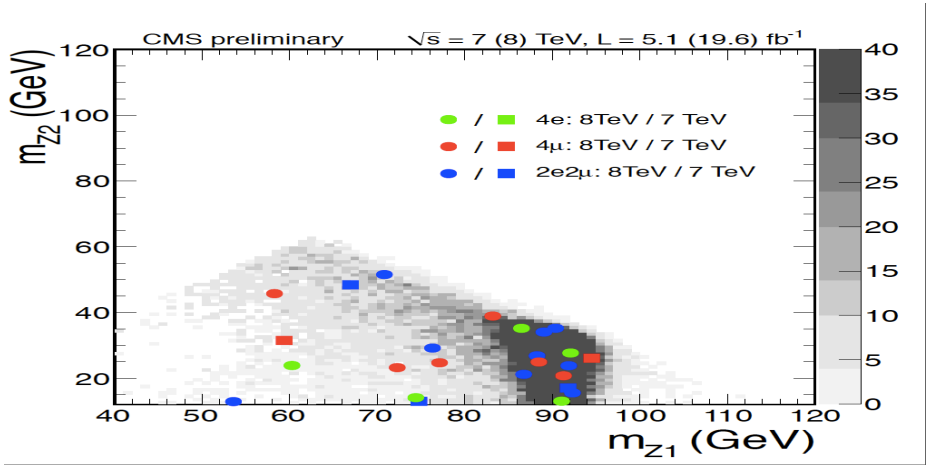


H→ZZ→4leptons



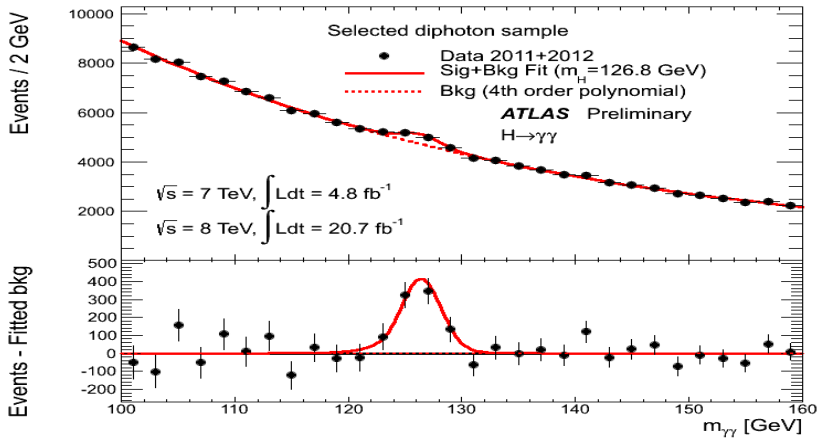


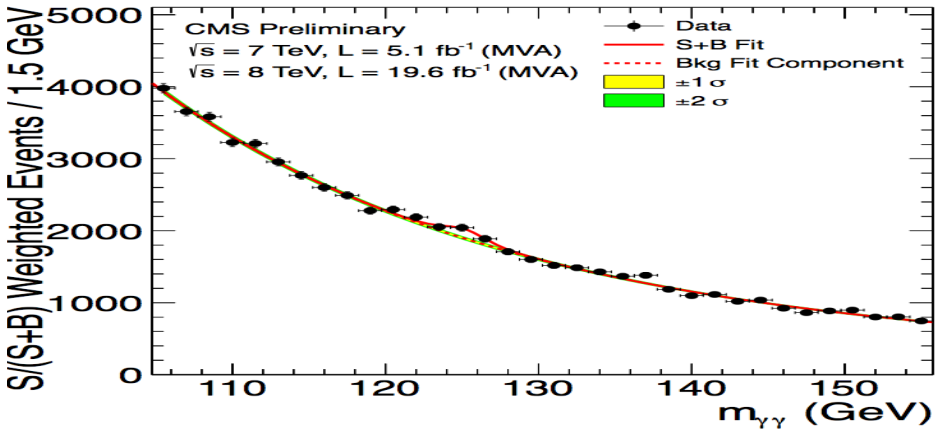


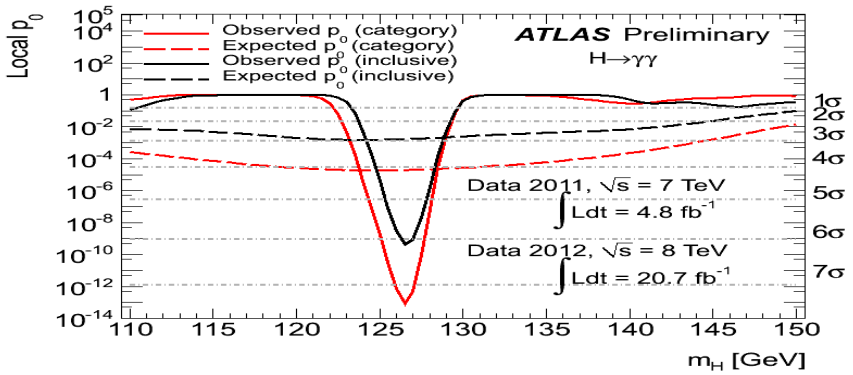


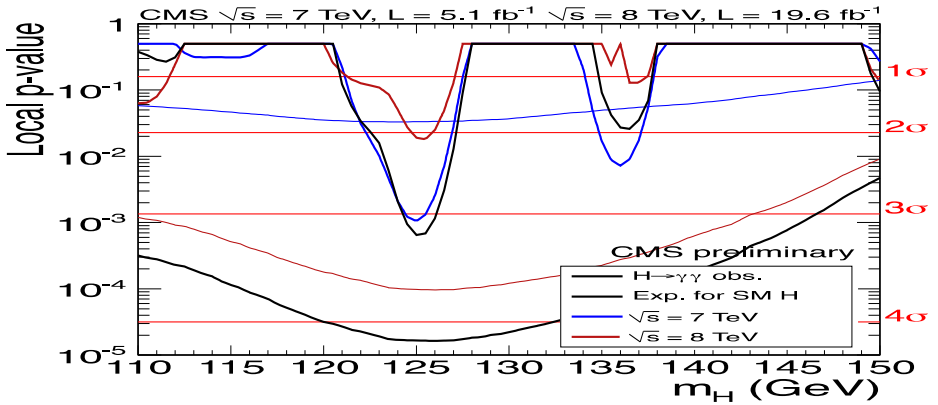
- Slight different Pt of leptons cuts: 20,15,7,7/6(ATLAS), 20,10,7,7/5 (CMS)
- Obsv/Exp: 6.6 σ/4.4 σ(ATLAS) and 7.2 σ/6.7 σ(CMS)
- ATLAS: $\mu = 1.7^{+0.5}_{-0.4}$, $m = 124.3^{+0.6}_{-0.5}{}^{+0.5}_{-0.3}$ GeV; CMS: $0.91^{+0.3}_{-0.24}$, $125.8 \pm 0.5 \pm 0.2$ GeV

H→γγ









- CMS: improved Ecal calibration, added more exclusive channels,similar to ATLAS.
- ATLAS:μ=1.64±0.34, m=126.8±0.7±0.2GeV
- CMS:0.78±0.27(MVA),1.11±0.31 (cut),consist at 2σ with 125.4±0.5±0.6 GeV

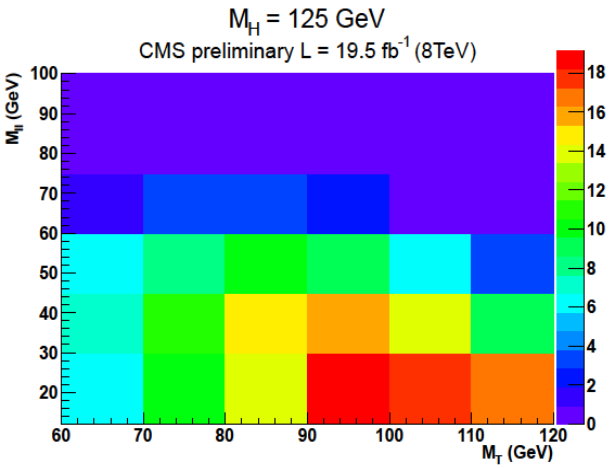
Significance@126.5: 7.4σ (4.1 exp.)

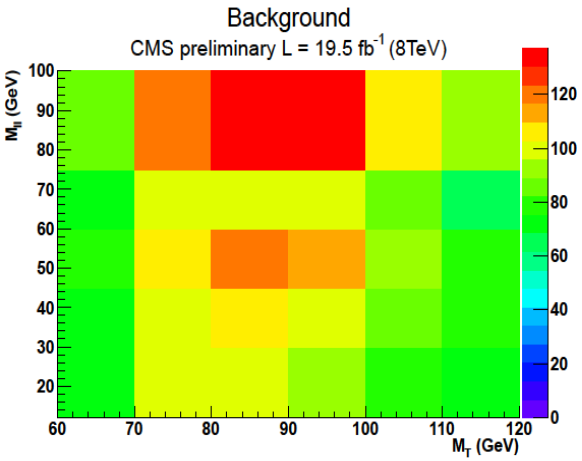
MVA Significance@125: 3.2 σ (4.2 exp.)

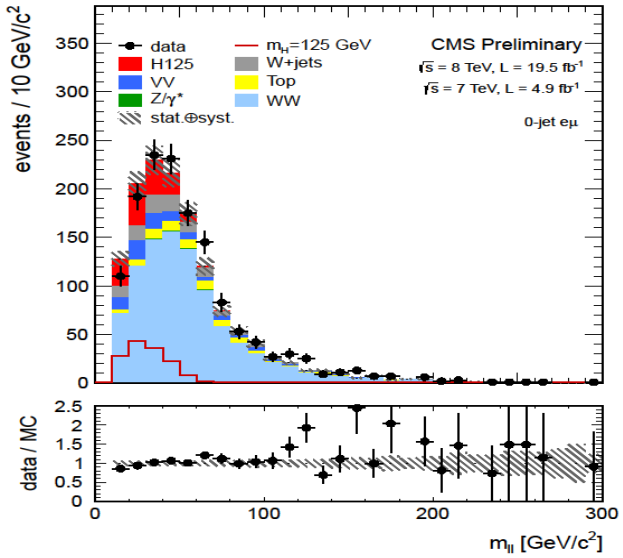
Cut-based p0 @124.5: 3.9 σ (3.5 exp.)

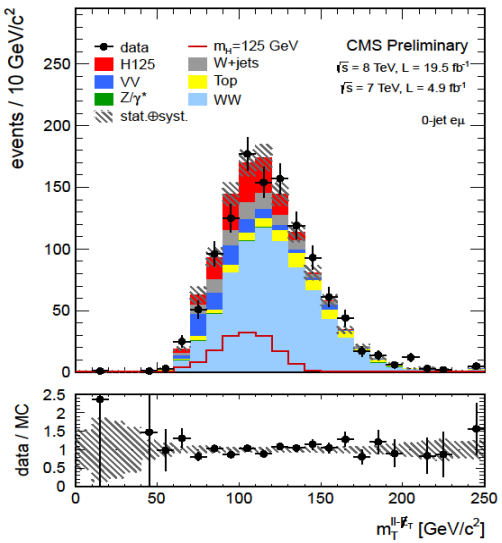
H→WW

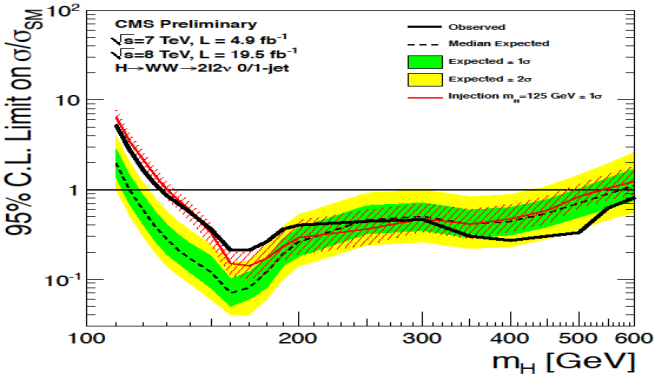
- Similar selections: 25/15 GeV(ATLAS), 23/10(CMS).
- CMS: 2d-fit of m_{ll} and m_T, ATLAS uses mT in 2bin m_{ll}



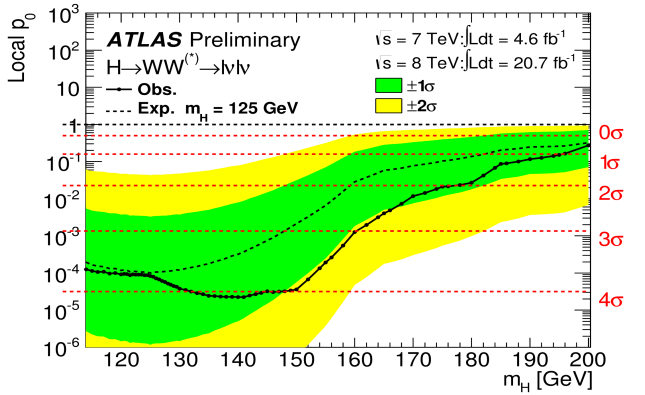






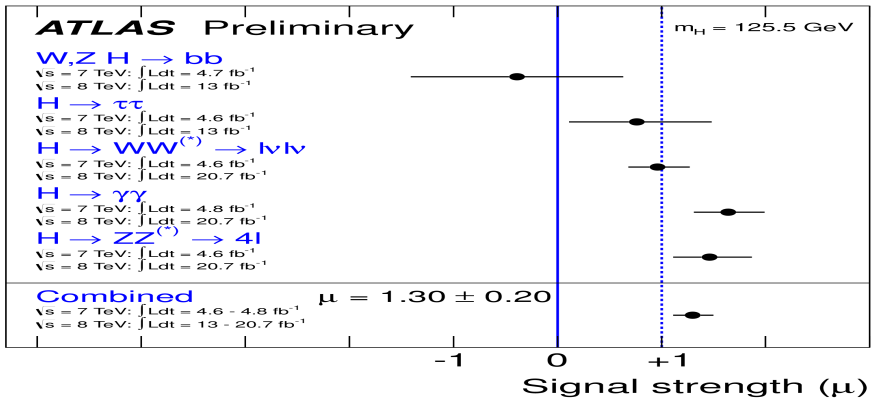


Significance @ 125 GeV:
4.0 σ (5.1 expected)
μ=0.76±0.21

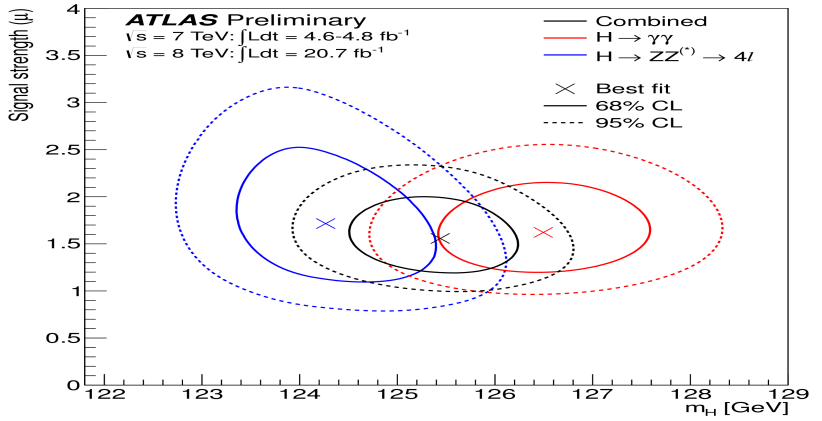


Significance @ 125 GeV:
3.8 σ (3.7 expected)
μ=0.83±0.36

Higgs Signal Rate and Mass

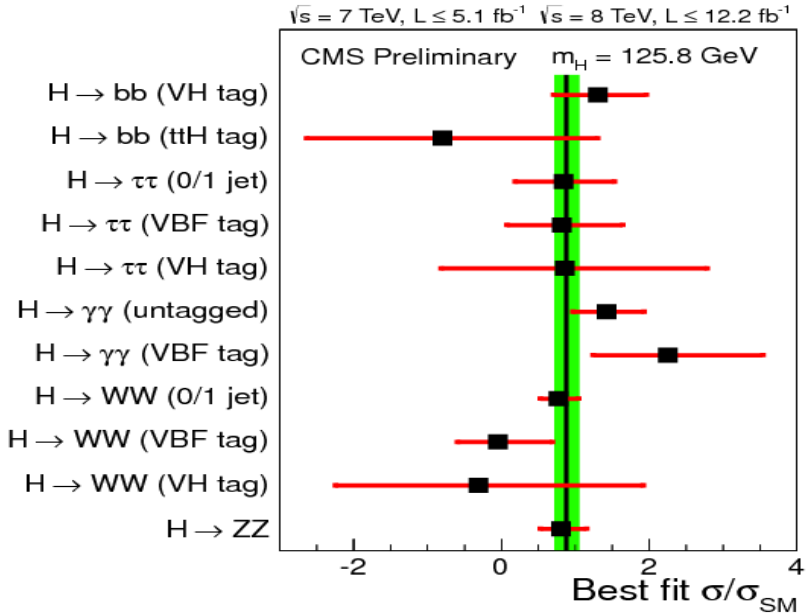


σ/σ_{sm}=1.30+-0.20

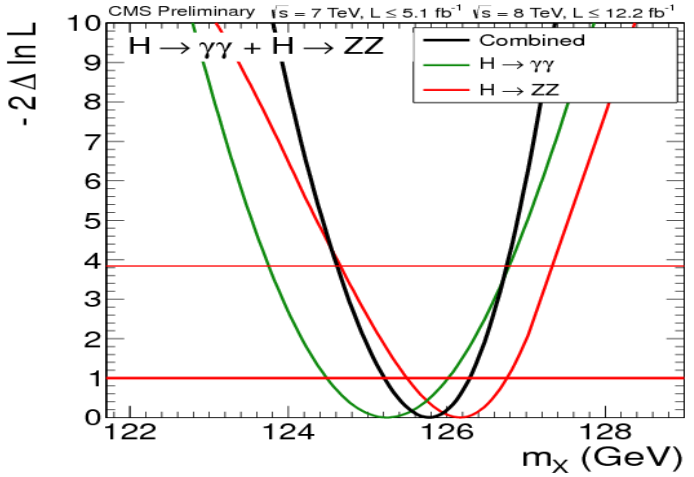


M_H=125.8+-0.2+-0.5 GeV

ΔM_H=2.3+-0.6+-0.6GeV(2.4σ)

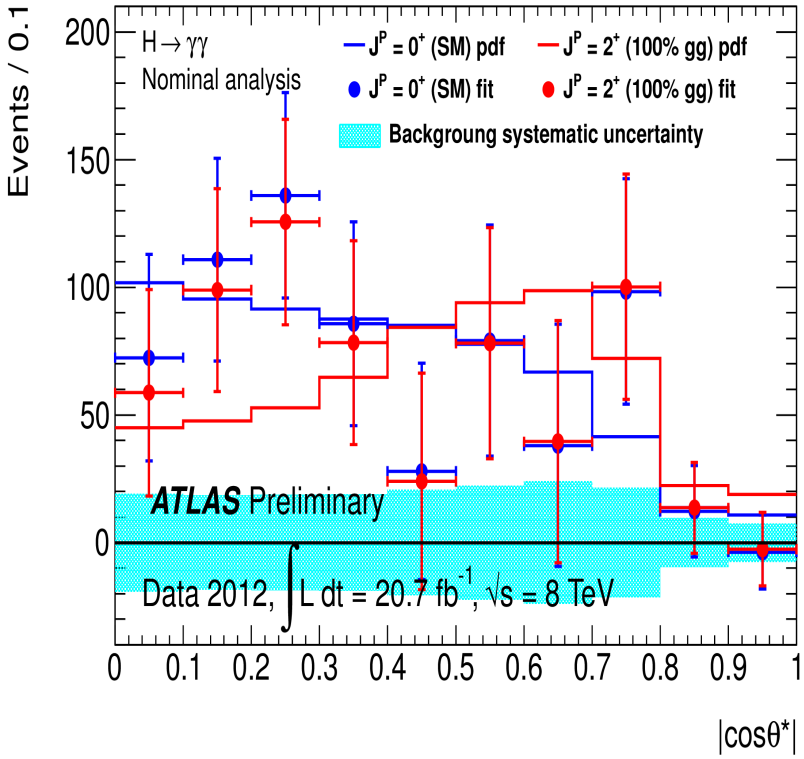


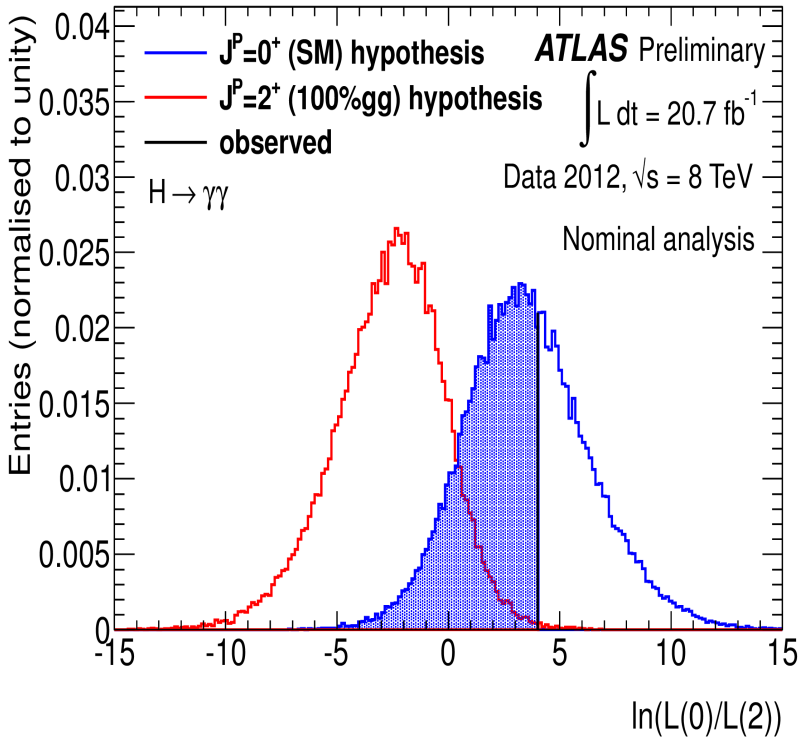
σ/σ_{sm}=0.88+-0.21



M_H=125.8+-0.4+-0.4 GeV

Spin-parity from H→γγ

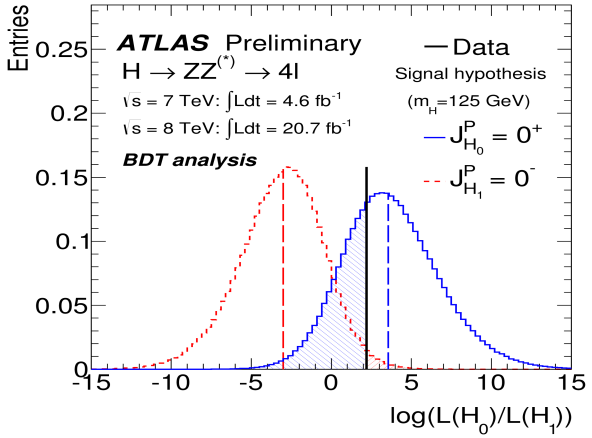


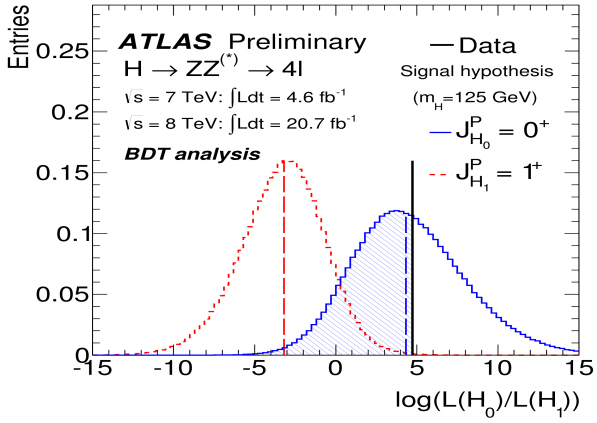


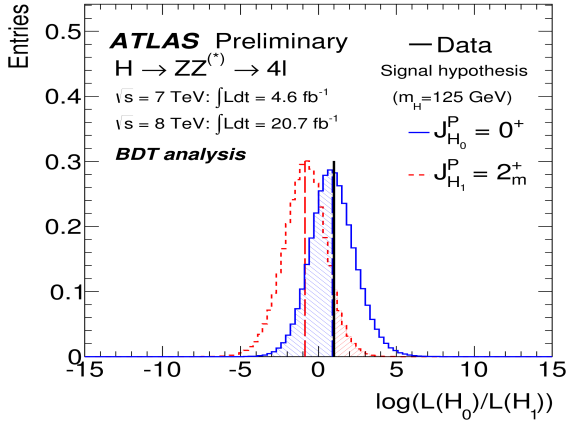
- Spin-2+ hypothesis expected exclusion Cls at 93%
- Observation compatible with spin-0+, slightly favored over spin-2+ hypothesis

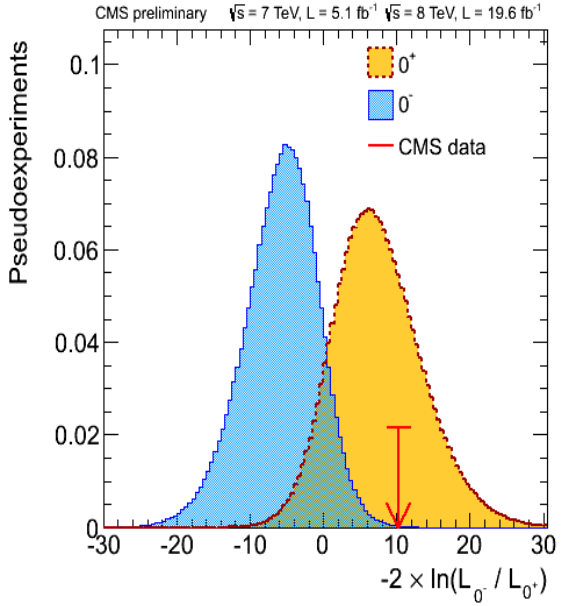
Spin-Parity from H→ ZZ

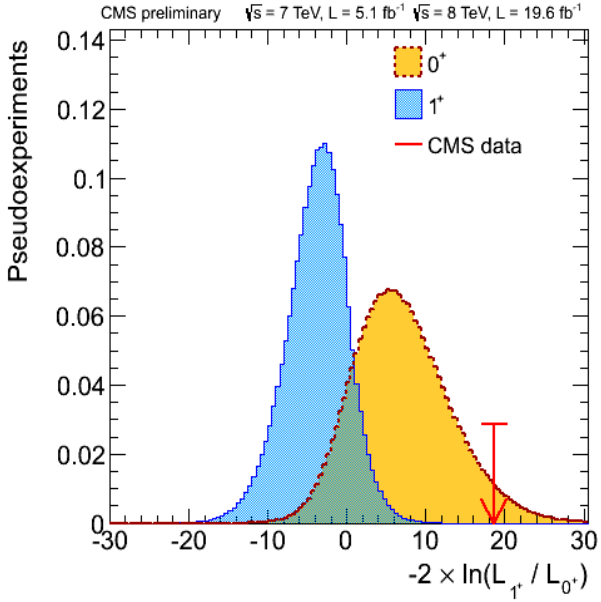
- Using kinematic distributions to do distinguish different signal models and both data are consistent with 0+ hypothesis.

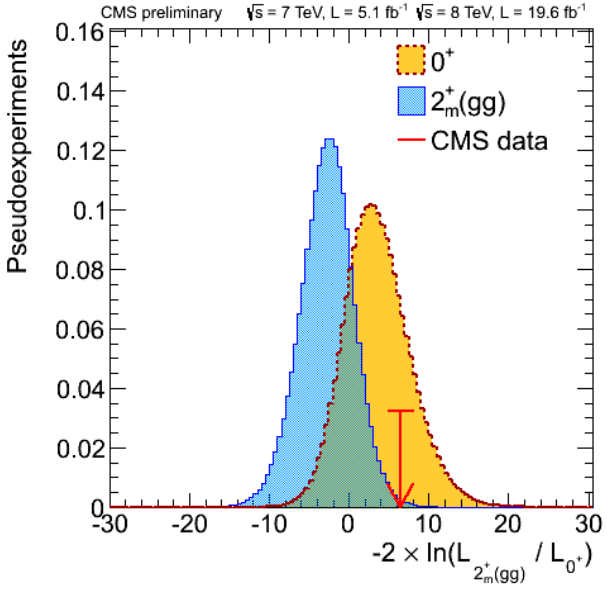






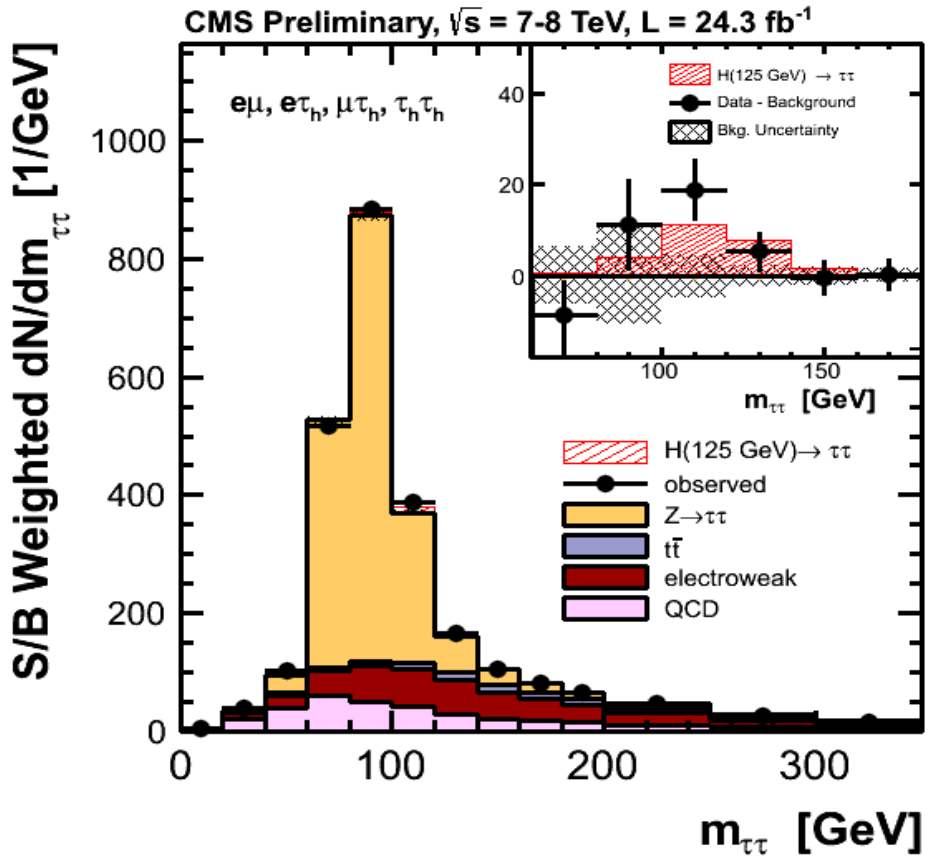


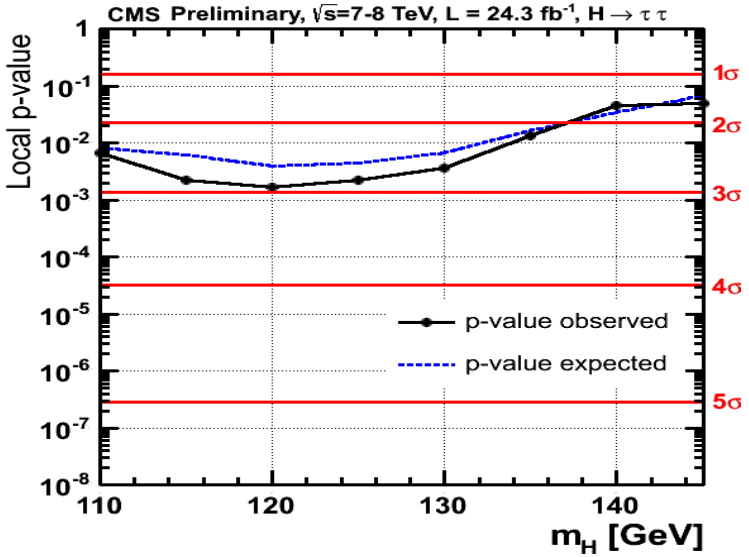


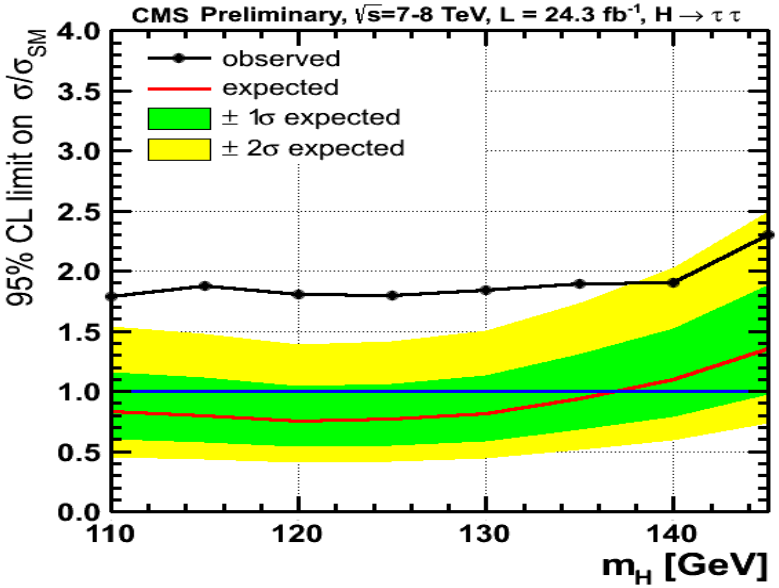


H→ττ

- Divided in five final states (ggH,VH, H→WW→lτx).
- Observed excess of 2.9σ, consistent with H(125).

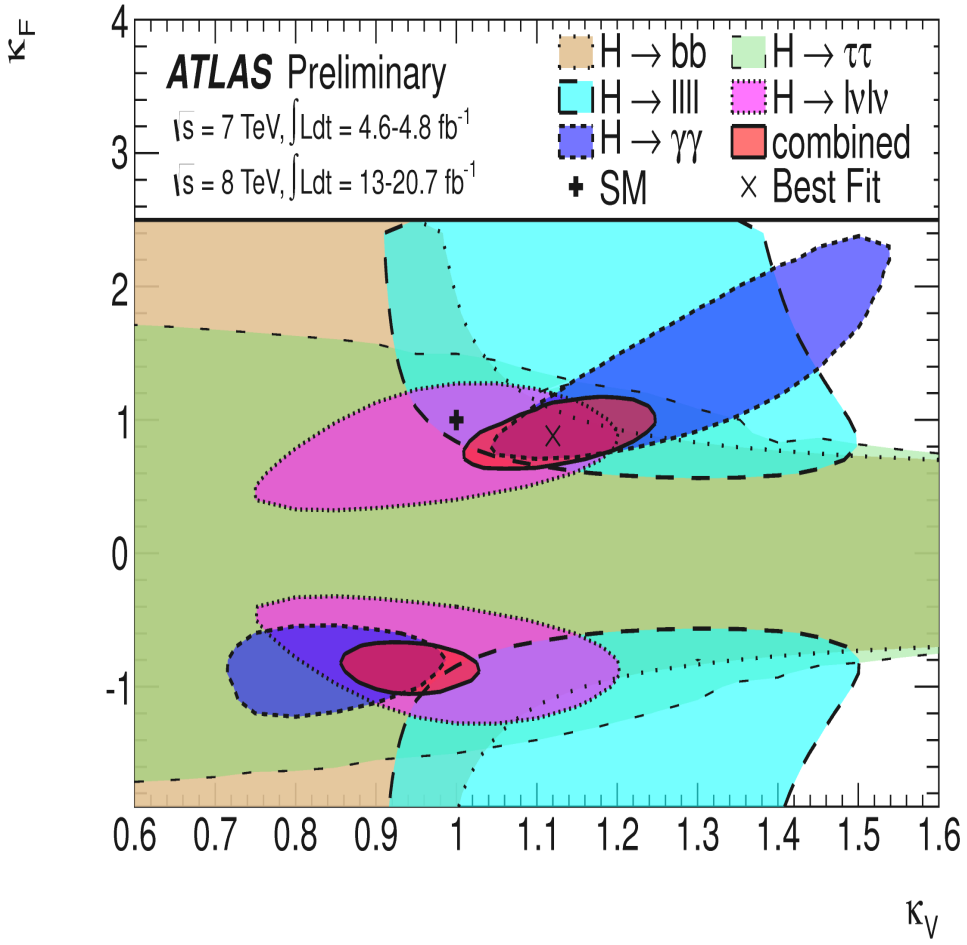


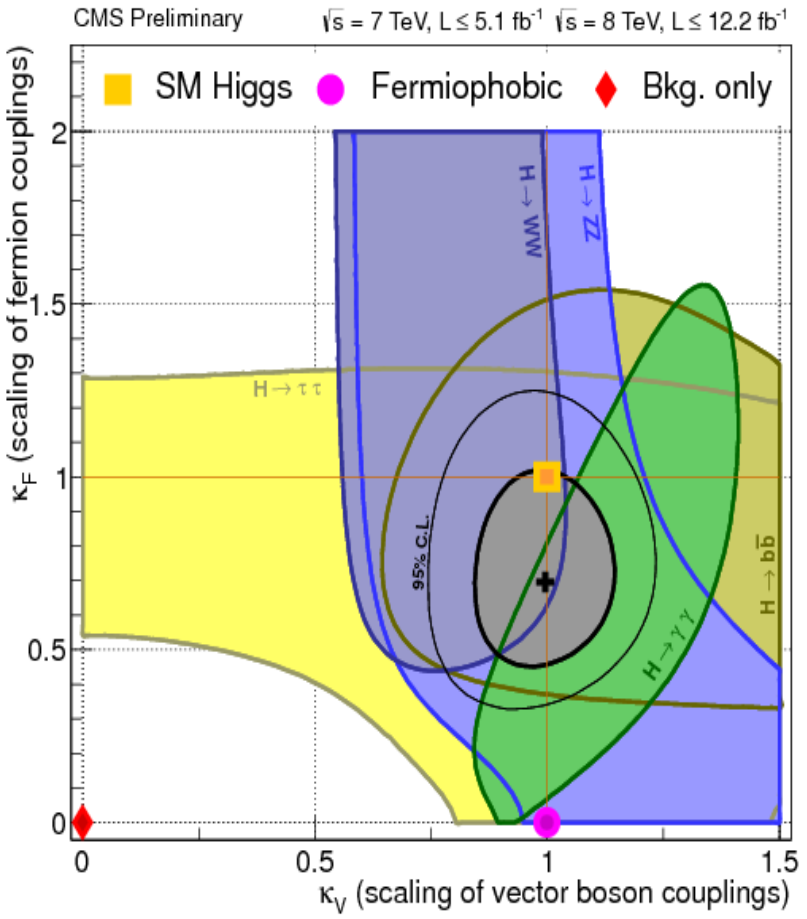




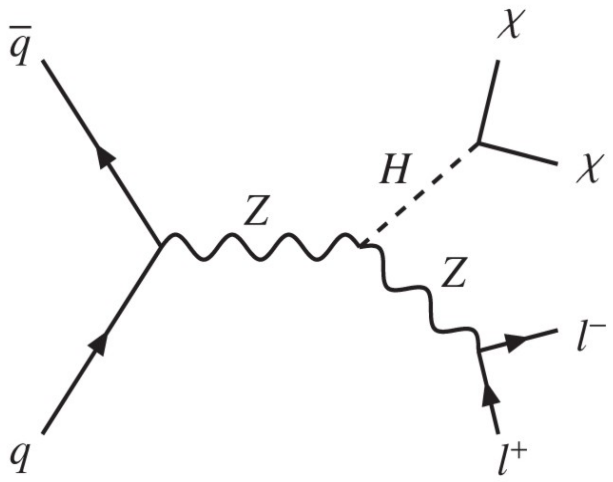
Higgs Coupling

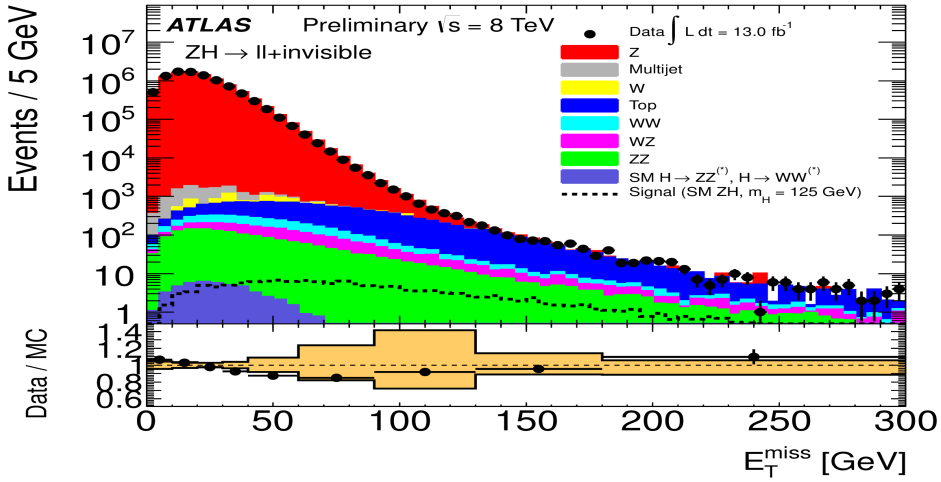
- Studies of the coupling will help to understand what the new particle is and can be parameterized through coupling factors respect to SM.
- Results are consistent with SM predictions.

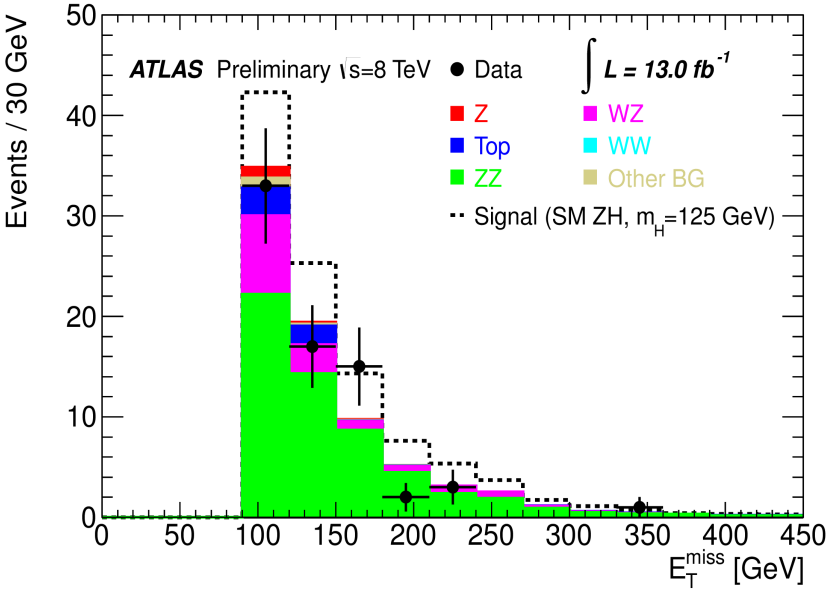


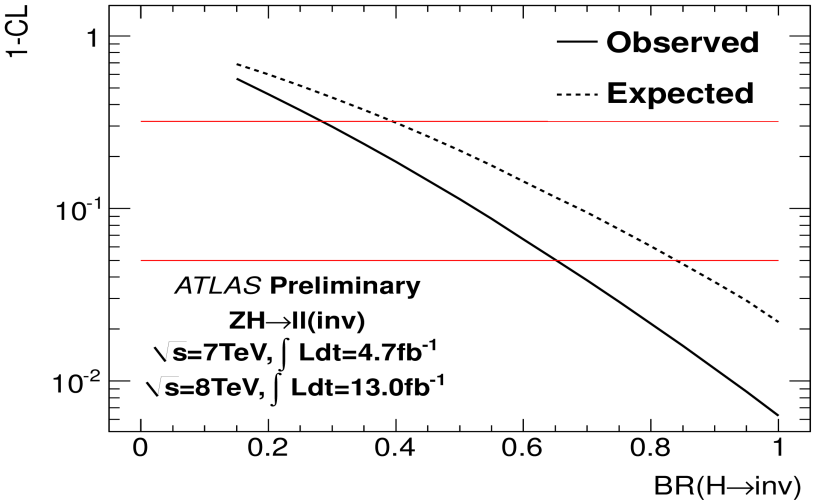


H→invisible search (ATLAS)



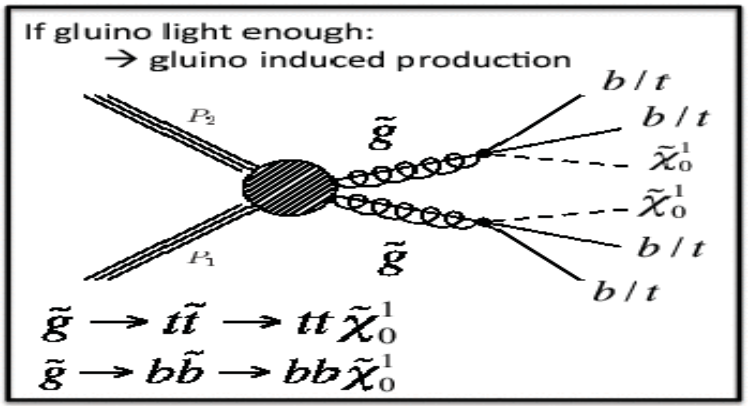


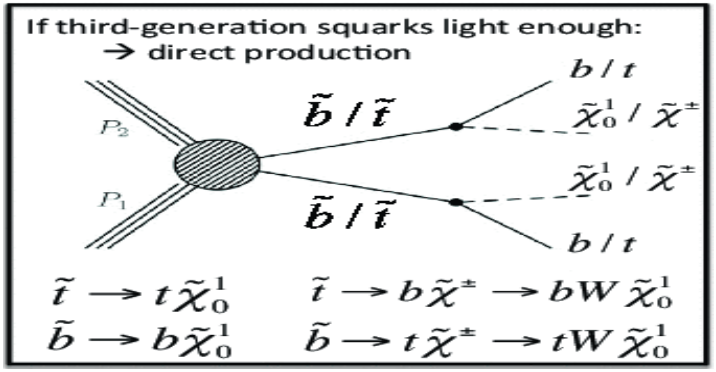


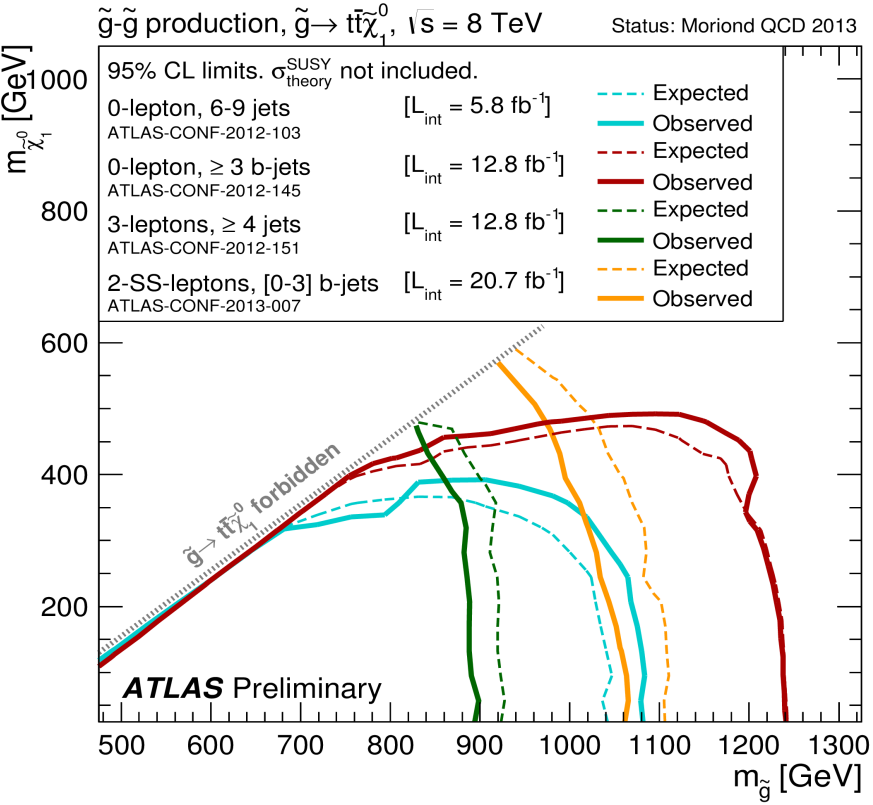


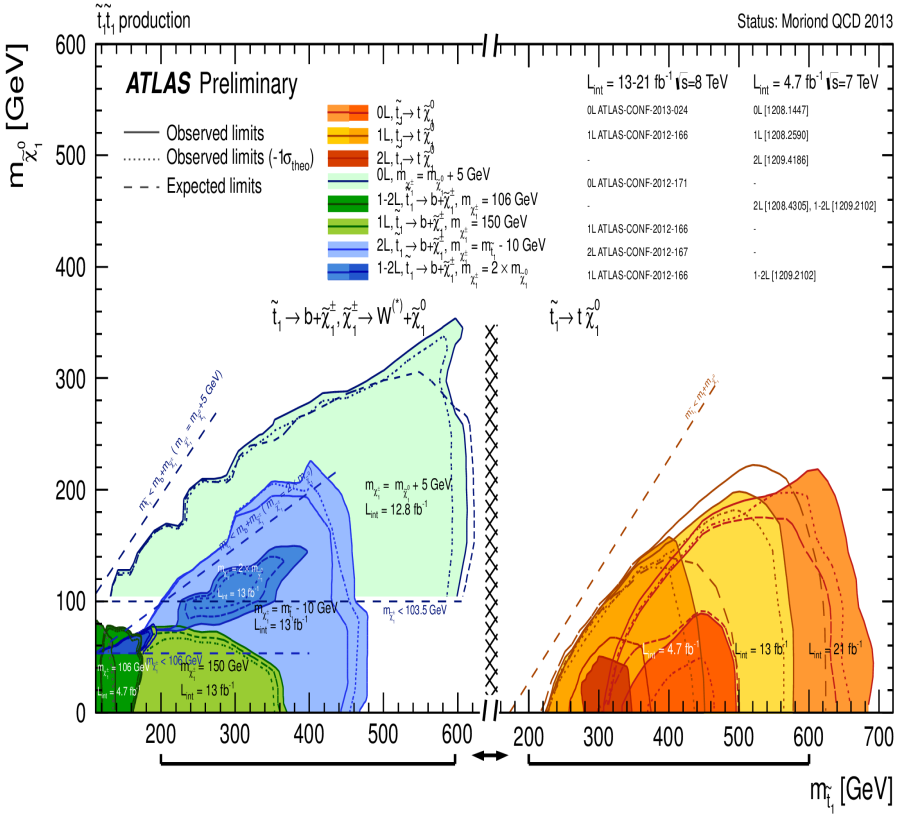
B(H→invisib)<65% @ 95%CL

Natural-SUSY searches

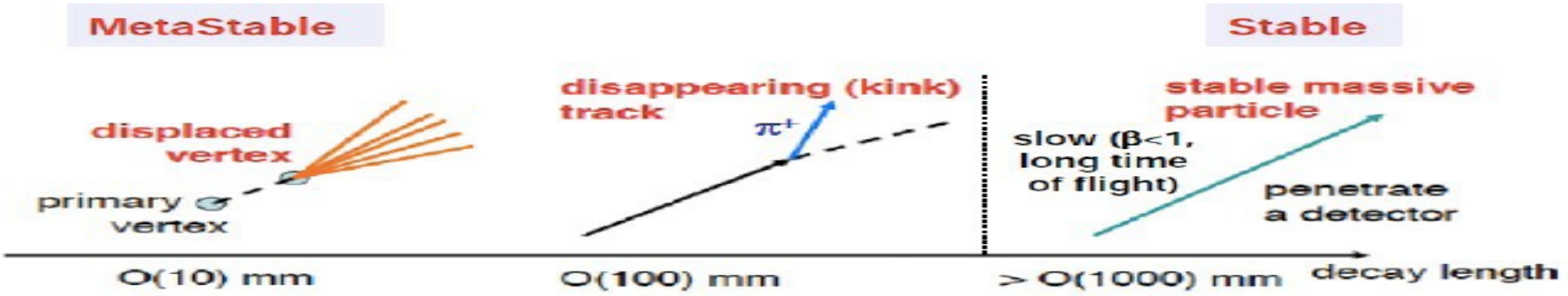


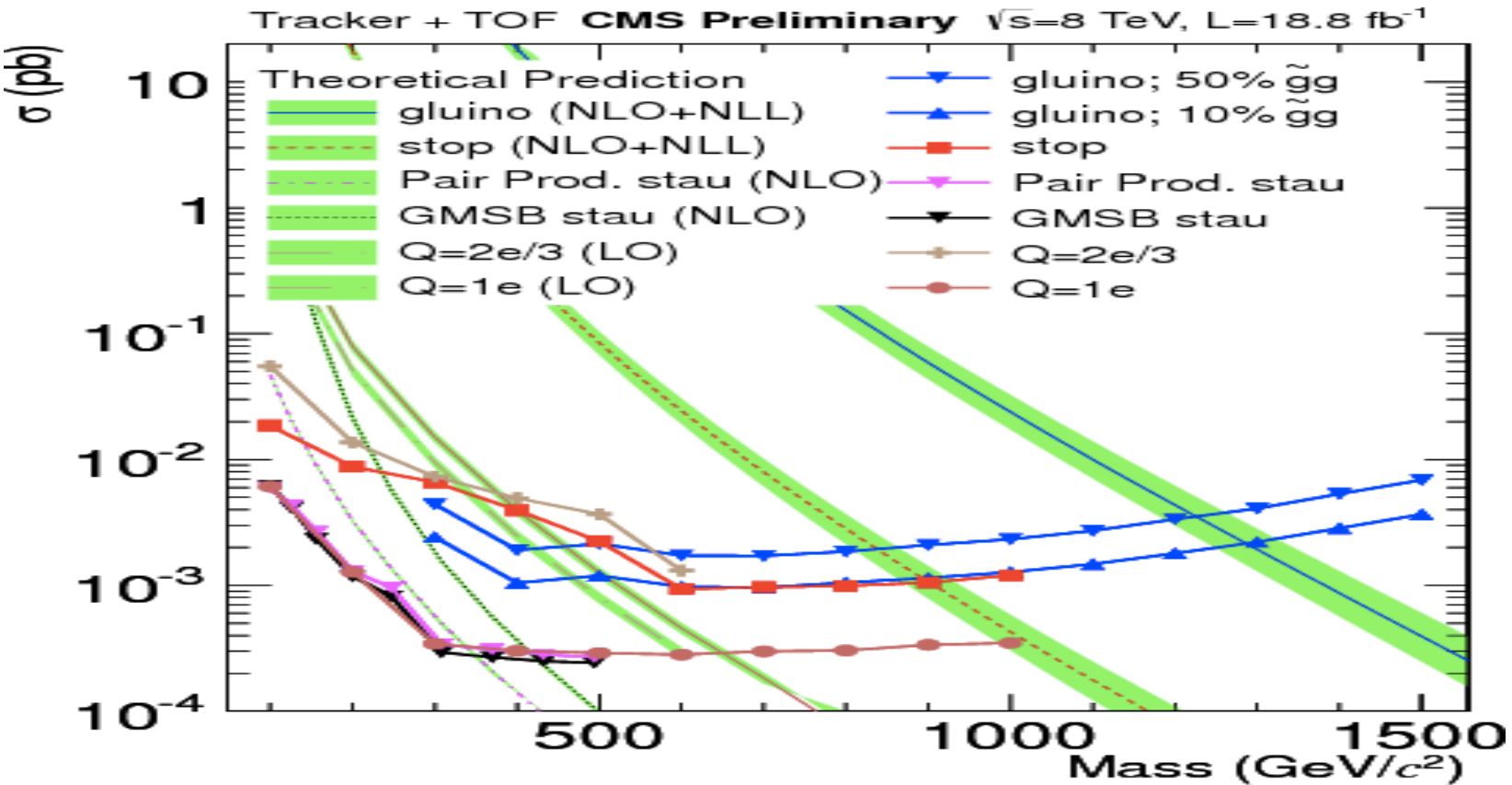




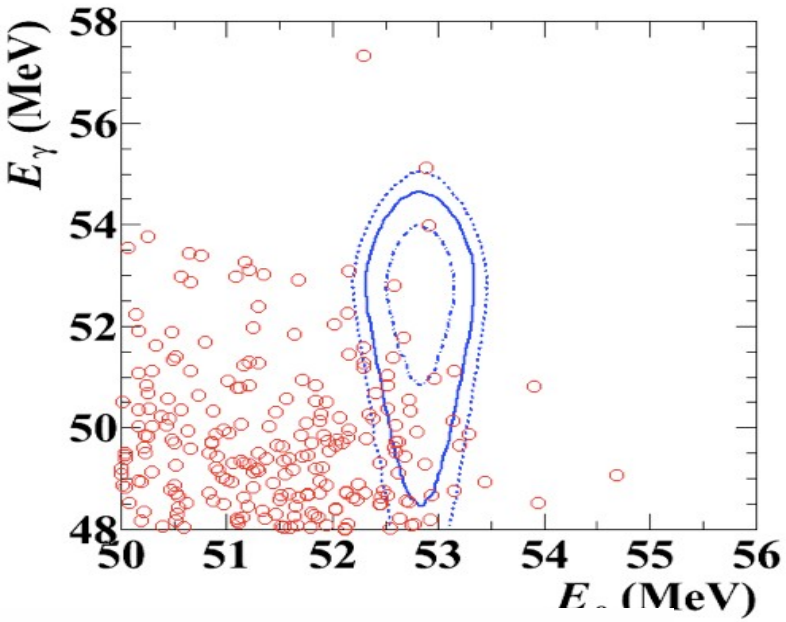


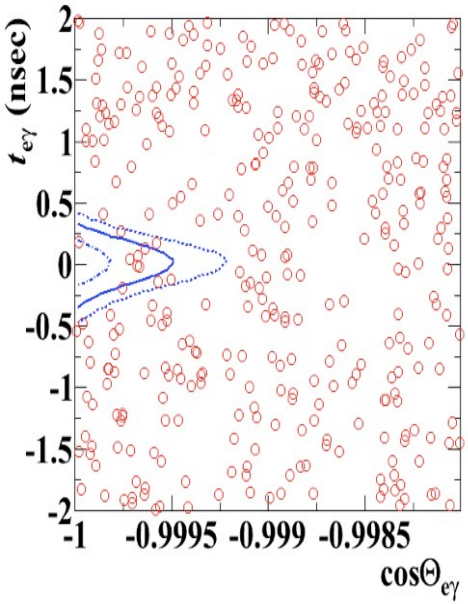
Non-MET SUSY

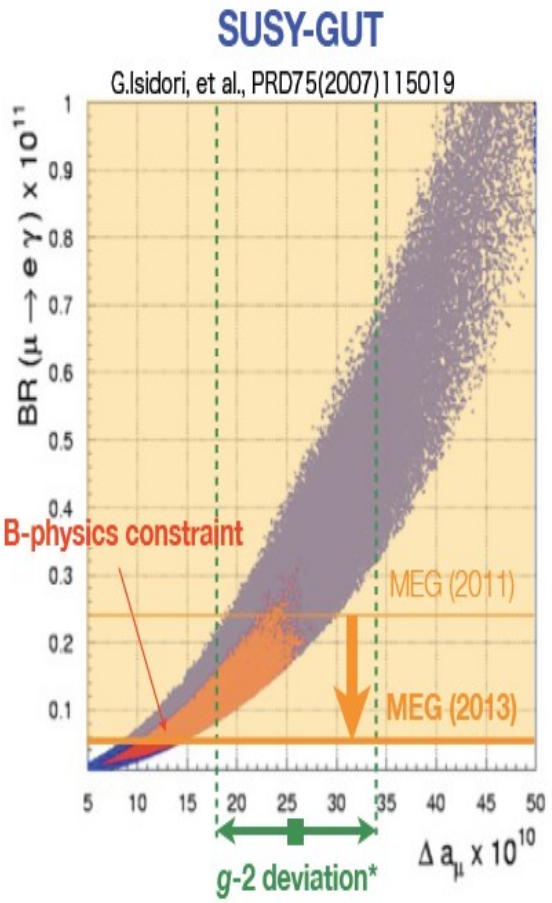

MetaStable
Stable
displaced vertex
primary vertex
disappearing (kink) track
π^+
stable massive particle
slow (β<1, long time of flight)
penetrate a detector
O(10) mm
O(100) mm
> O(1000) mm
decay length

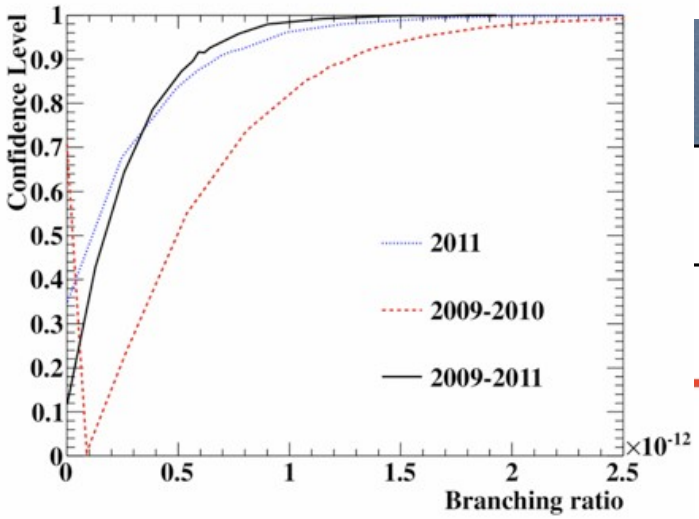

Tracker + TOF CMS Preliminary $\sqrt{s}$=8 TeV, L=18.8 fb^{-1}
σ (pb)
Theoretical Prediction
gluino (NLO+NLL)
stop (NLO+NLL)
Pair Prod. stau (NLO)
GMSB stau (NLO)
Q=2e/3 (LO)
Q=1e (LO)
gluino; 50% $\tilde{g}g$
gluino; 10% $\tilde{g}g$
stop
Pair Prod. stau
GMSB stau
Q=2e/3
Q=1e
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
500
1000
1500
Mass (GeV/c^2)

μ→eγ (MEG)



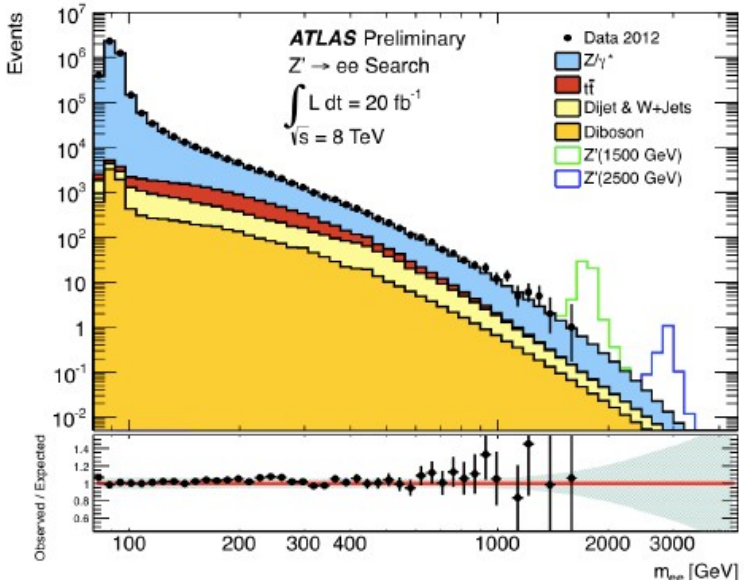


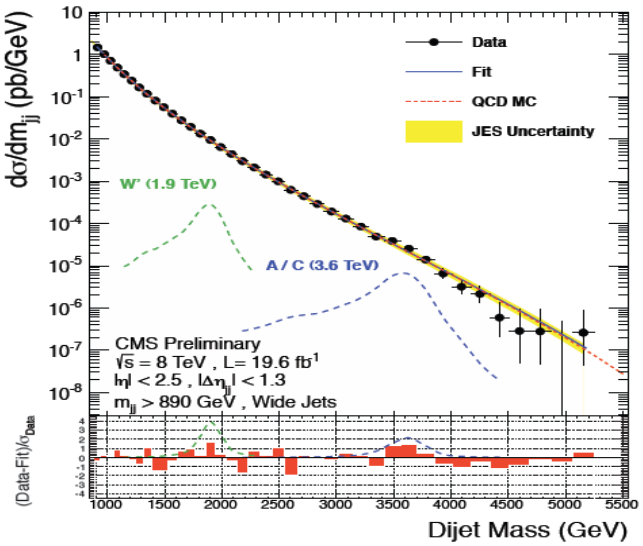


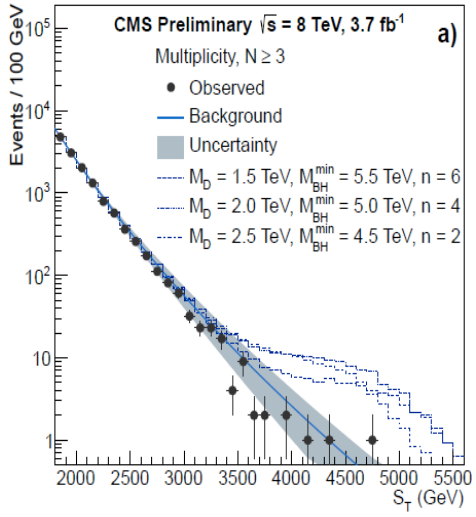


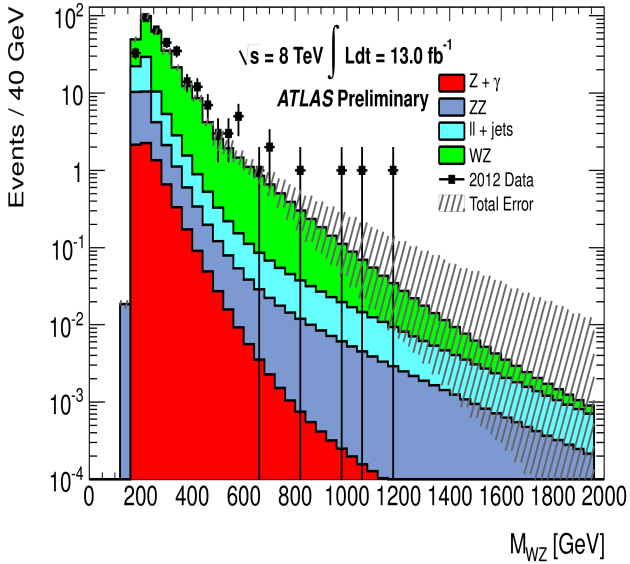
Upper limit (90% C.L.)	Sensitivity
1.3×10^{-12}	1.3×10^{-12}
6.7×10^{-13}	1.1×10^{-12}
5.7×10^{-13}	7.7×10^{-13}

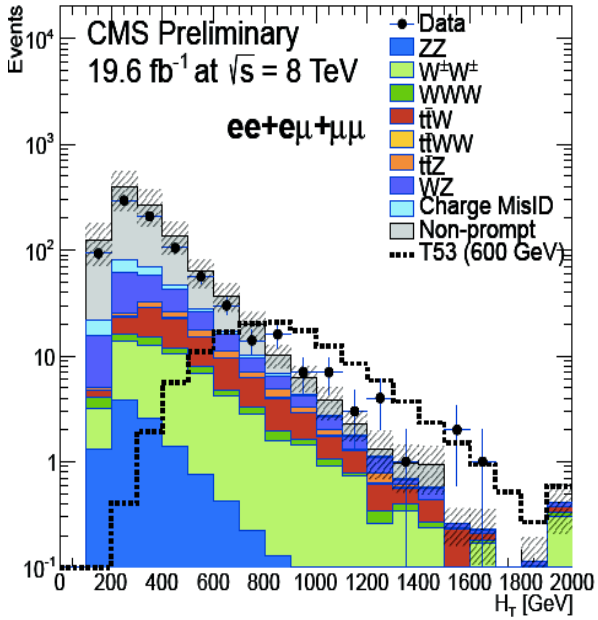
Other Searches

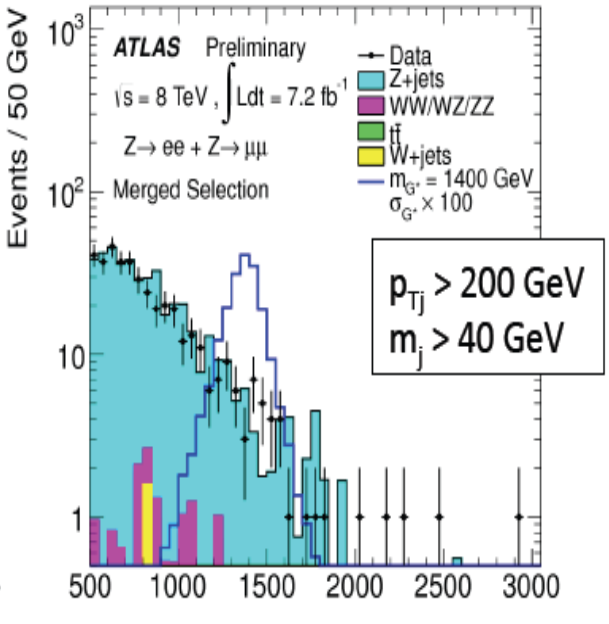




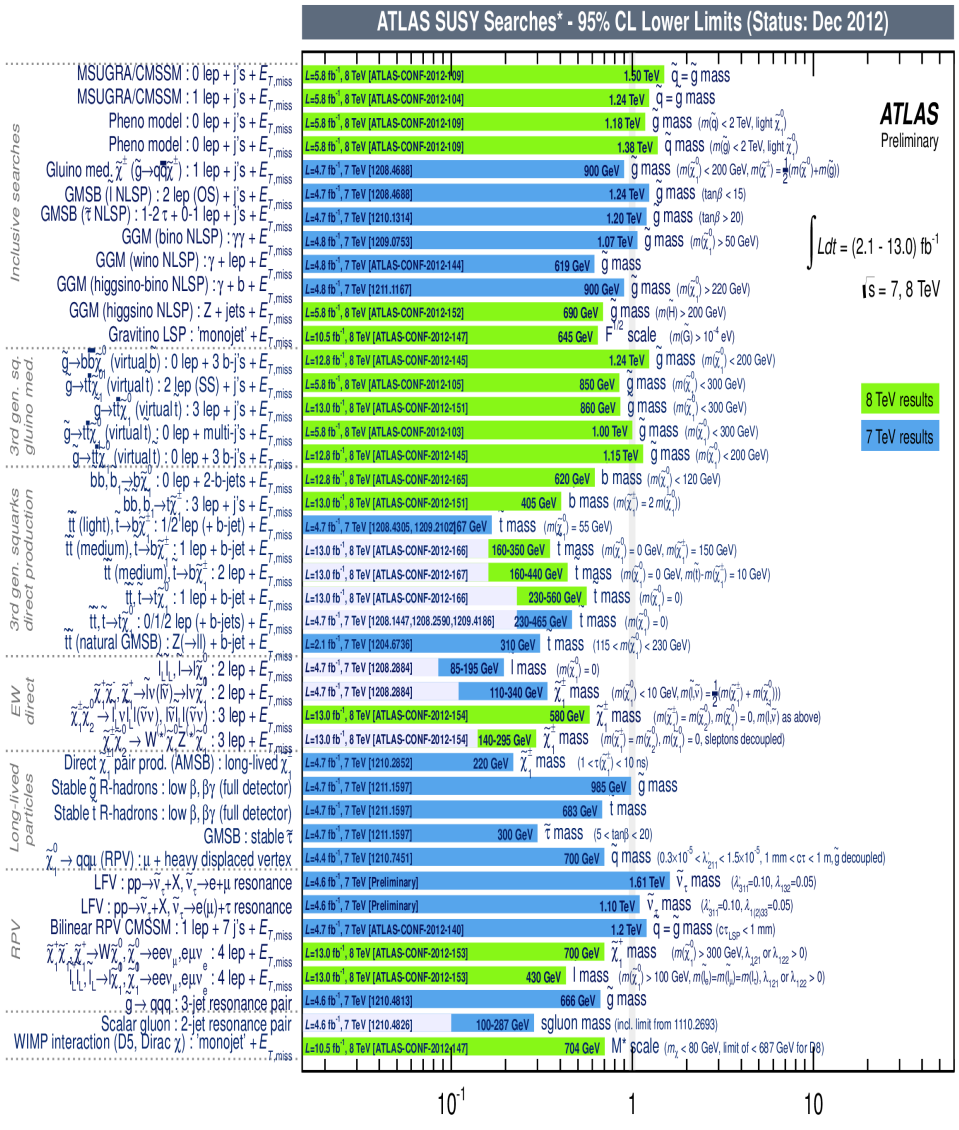




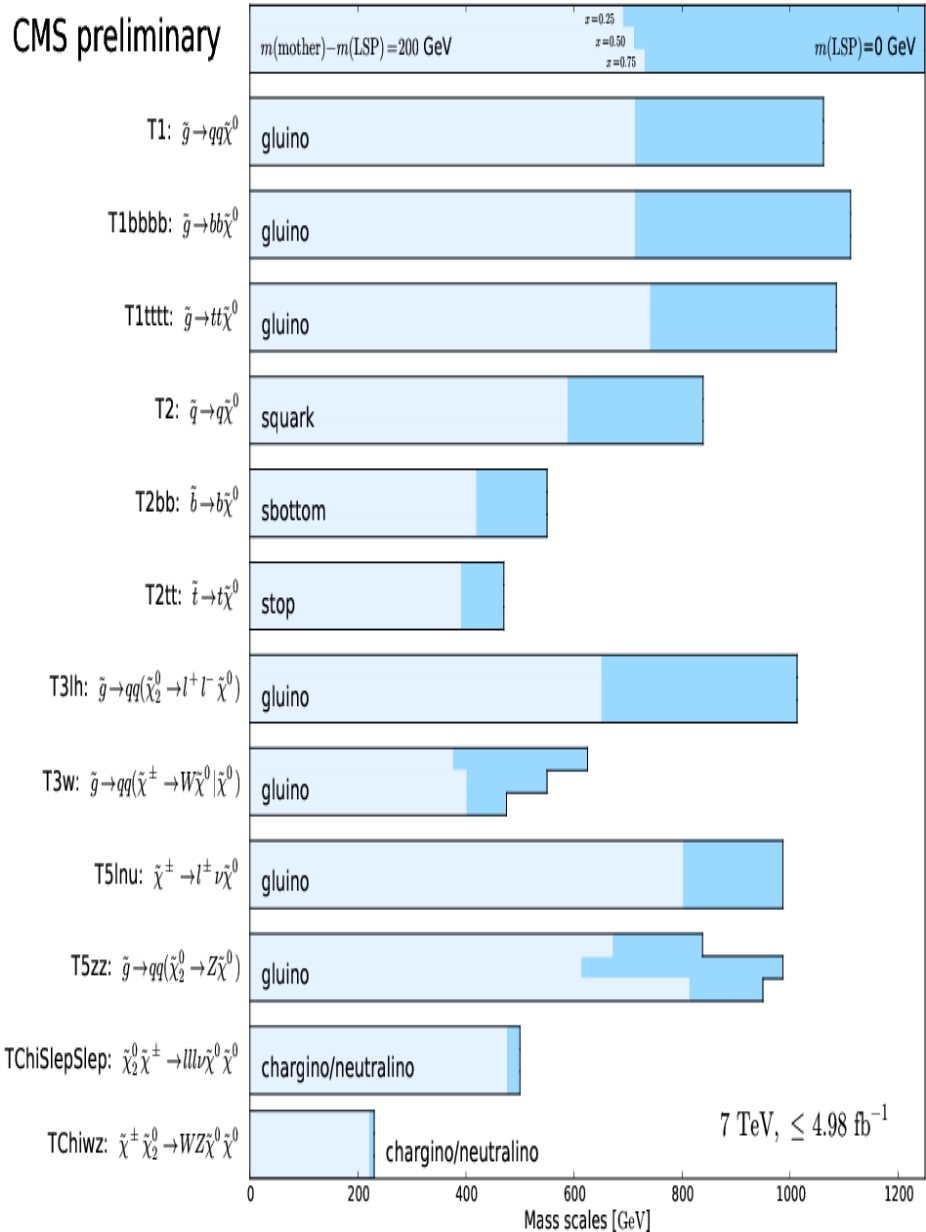




Summary of BSM Searches

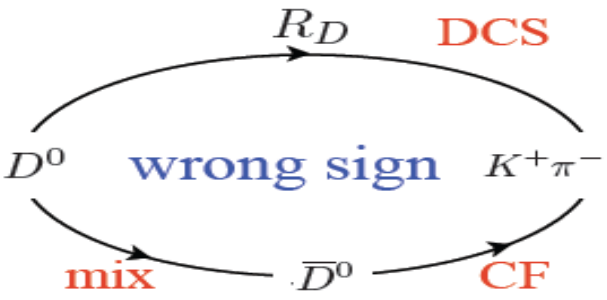


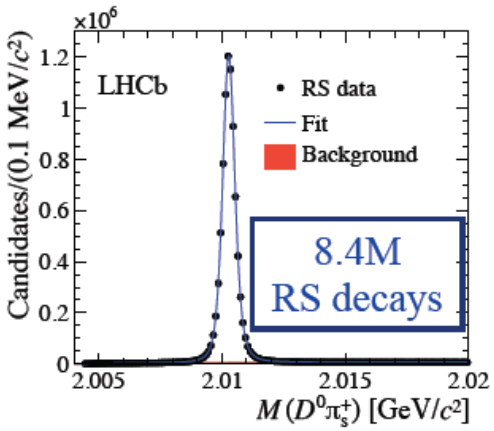
*Only a selection of the available mass limits on new states or phenomena shown.
All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

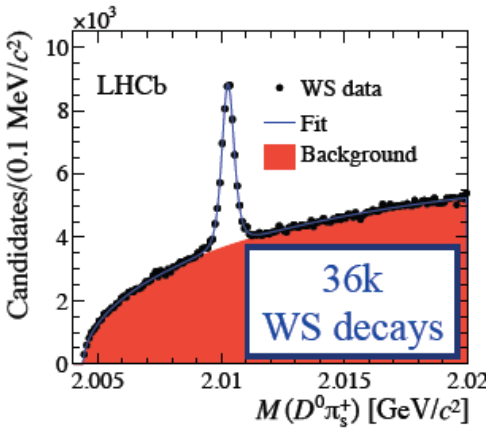


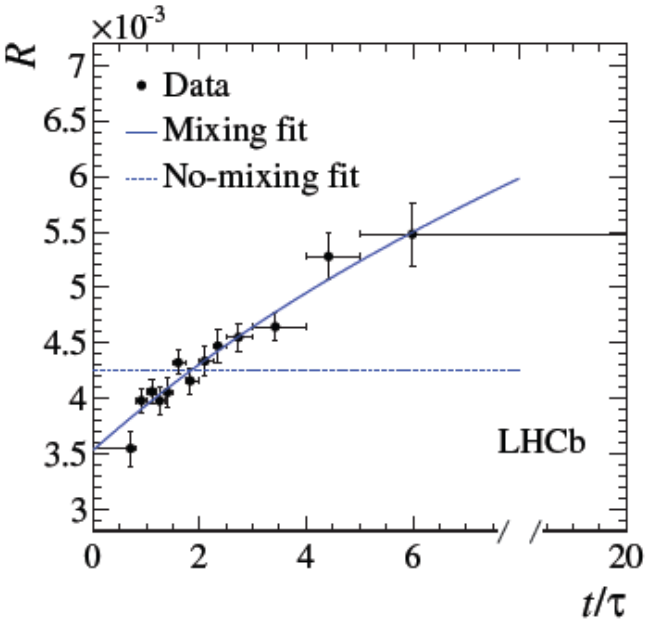
Backup

D0 Mixing (LHCb)

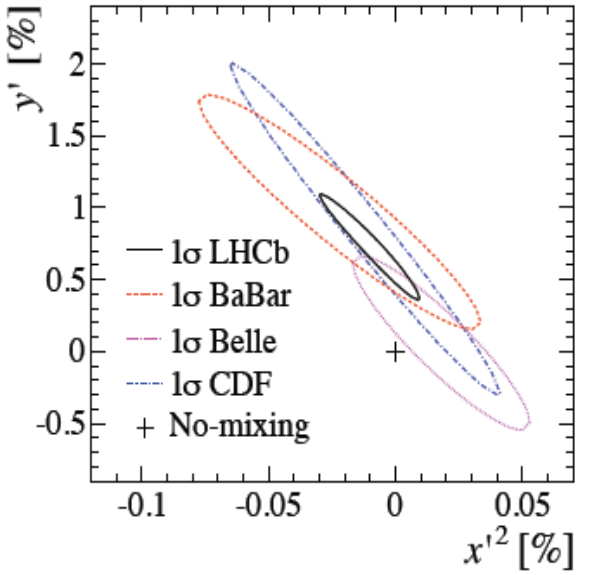








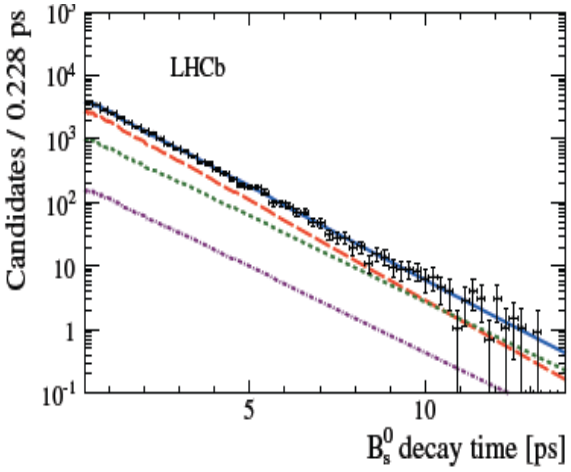
No mixing is excluded
At 9.1sigma

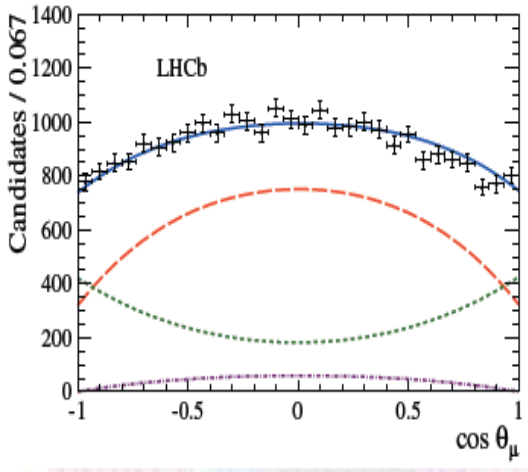


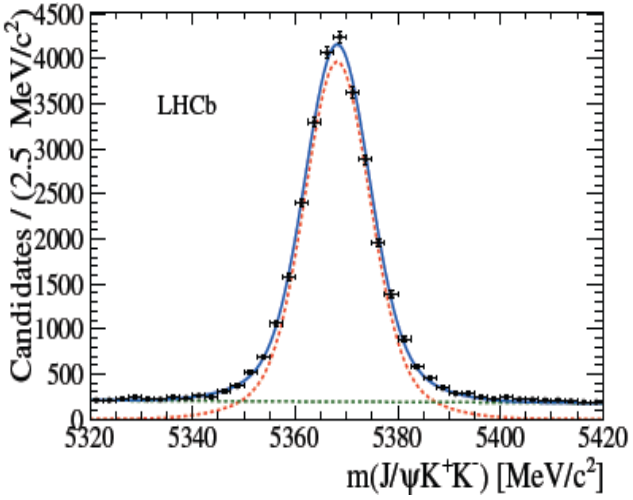
$$R(t) \approx R_D + \sqrt{R_D}\, y' \frac{t}{\tau} + \frac{x'^2 + y'^2}{4} \left(\frac{t}{\tau}\right)^2$$

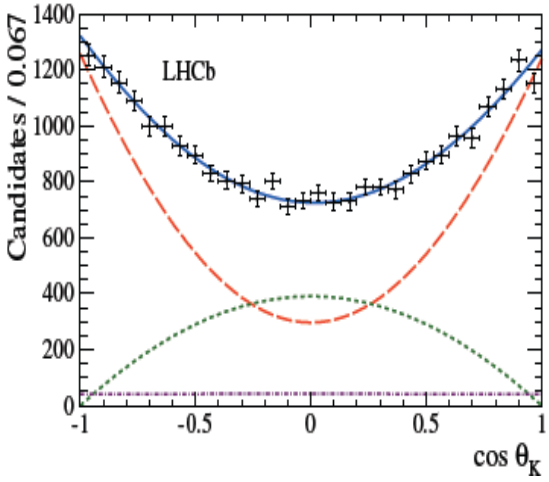
CPV in Bs→J/ψφ (LHCb)

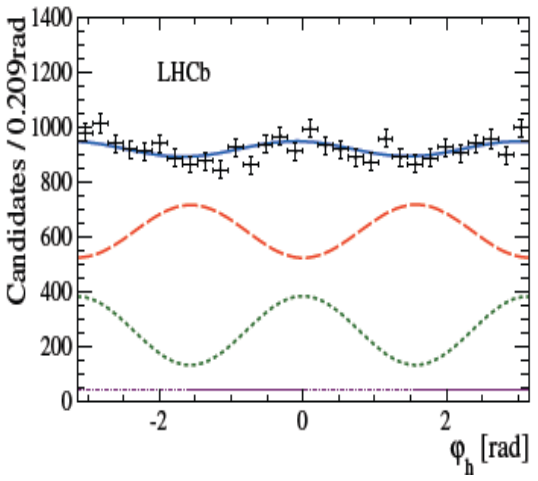
- Measurement based on 1.0 fb-1 data, mixture of CP-even, CP-odd, S-wave.
- Full angular analysis in helicity basis is employed.

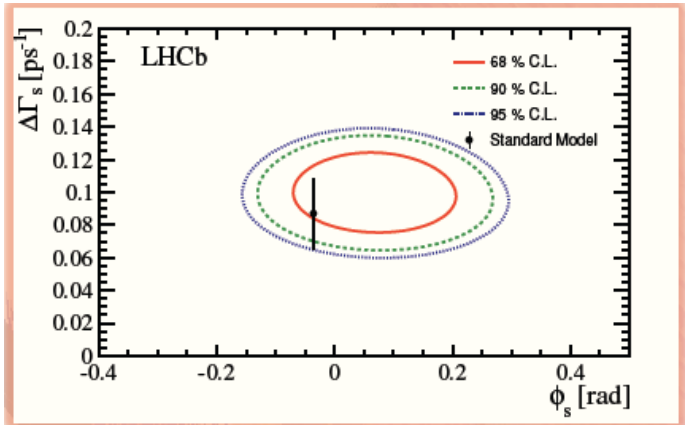




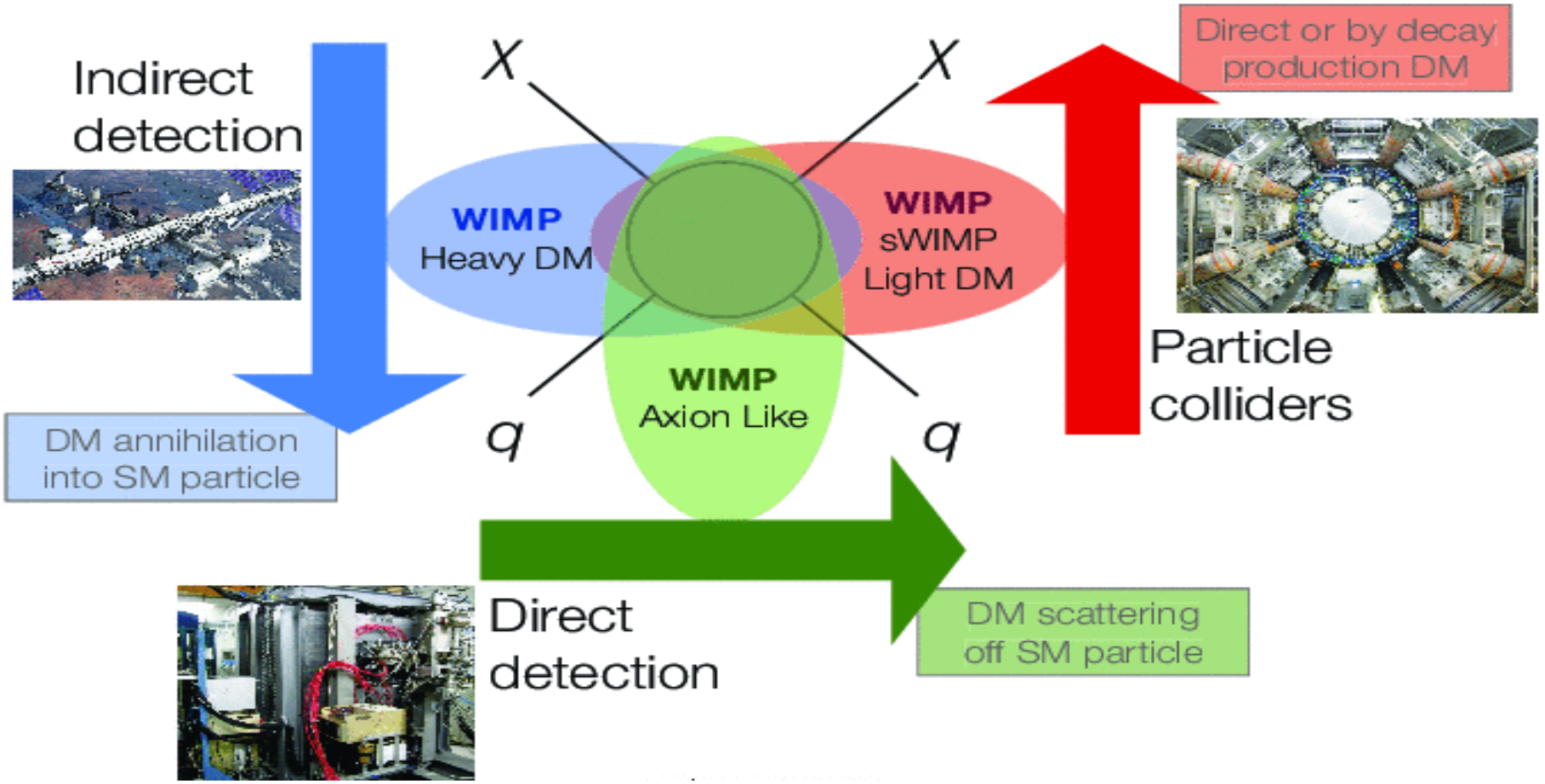




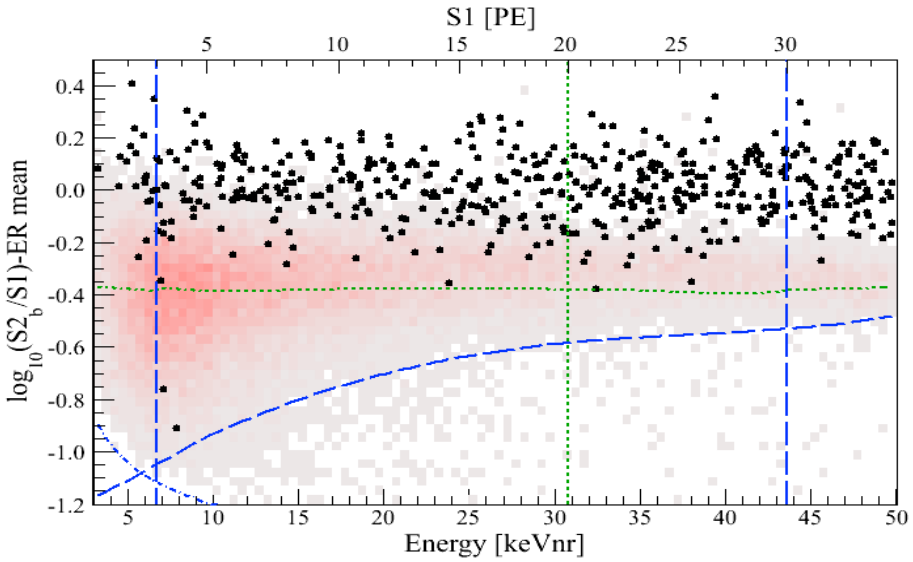


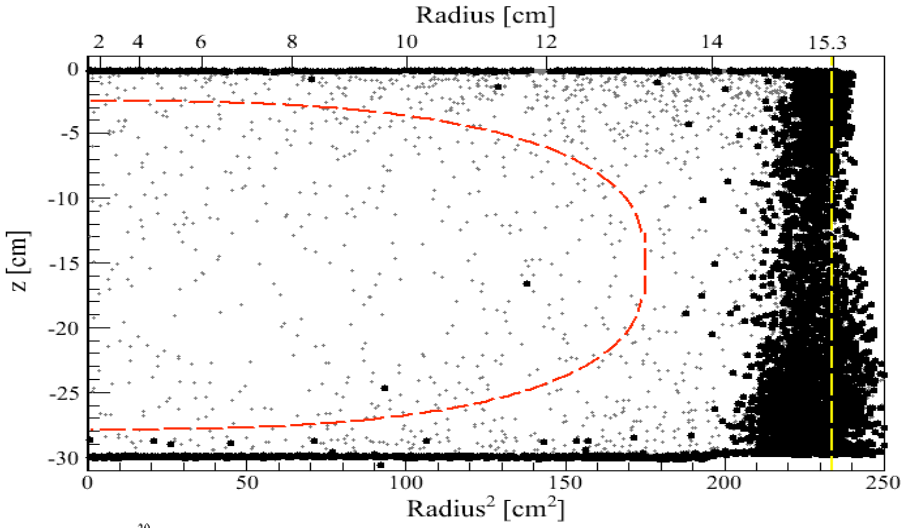


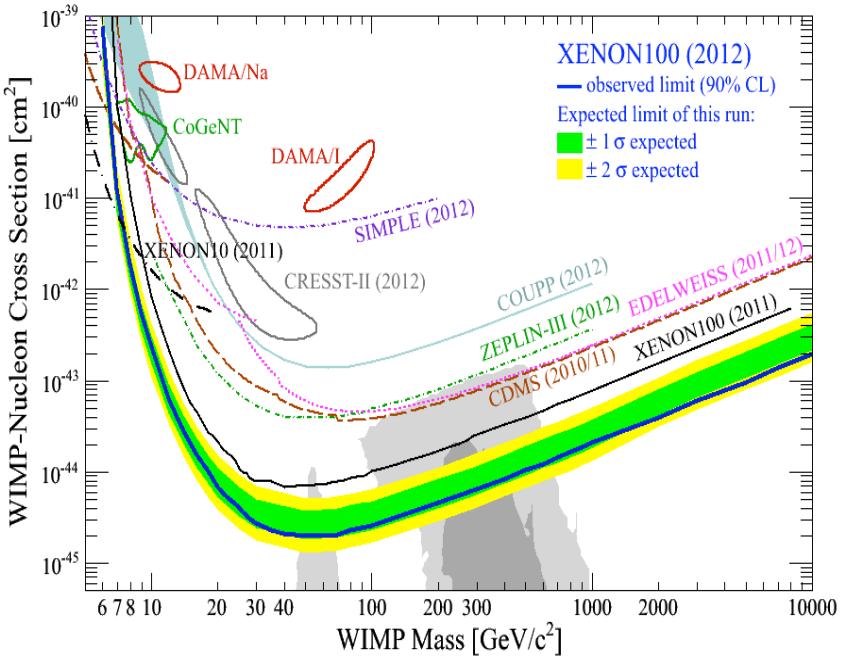
Dark Matter Searches

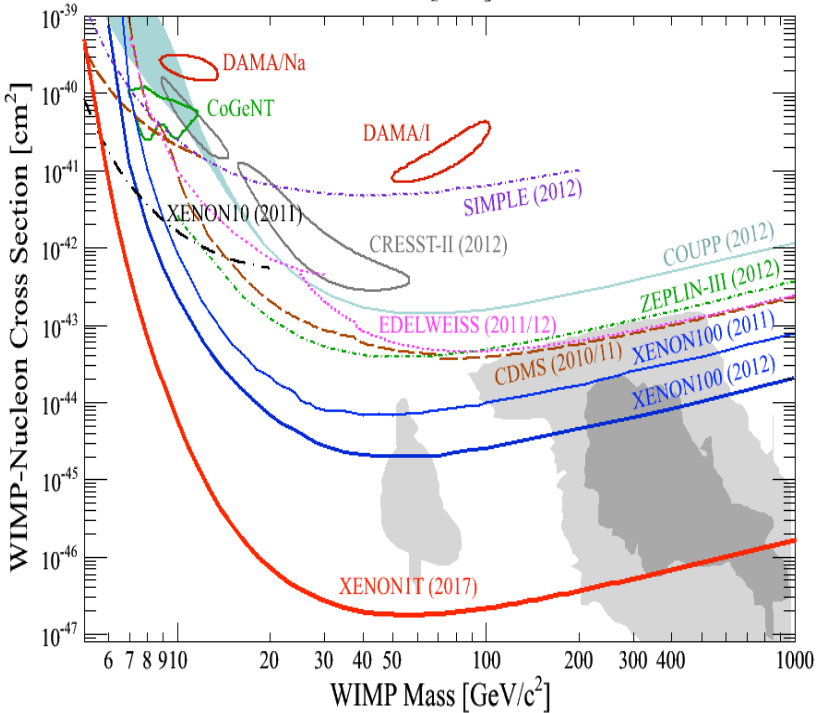


Dark Matter Searches (XENON100)

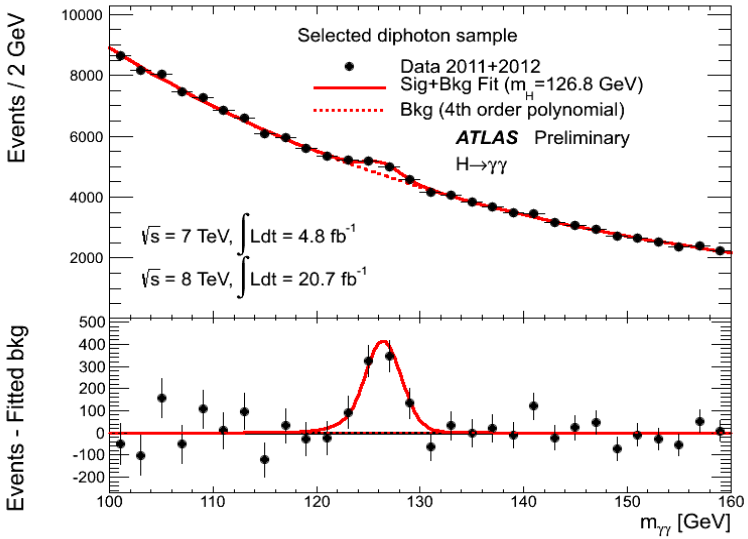




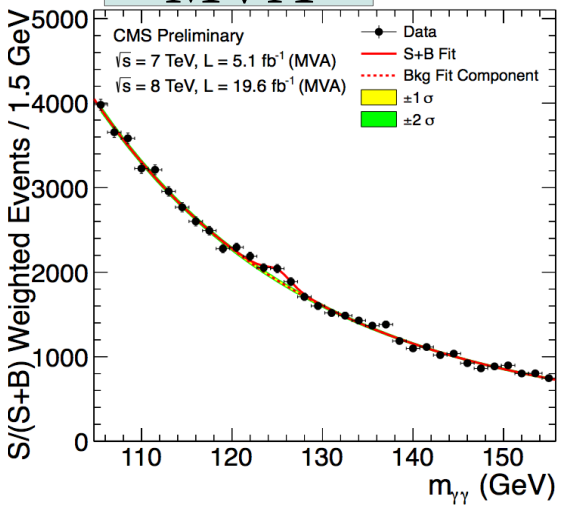




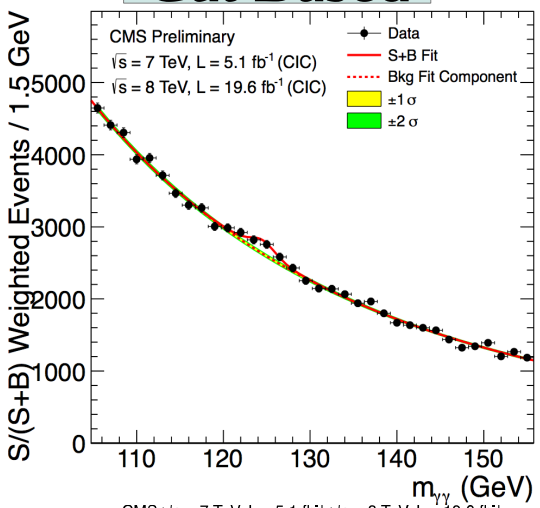
H→γγ

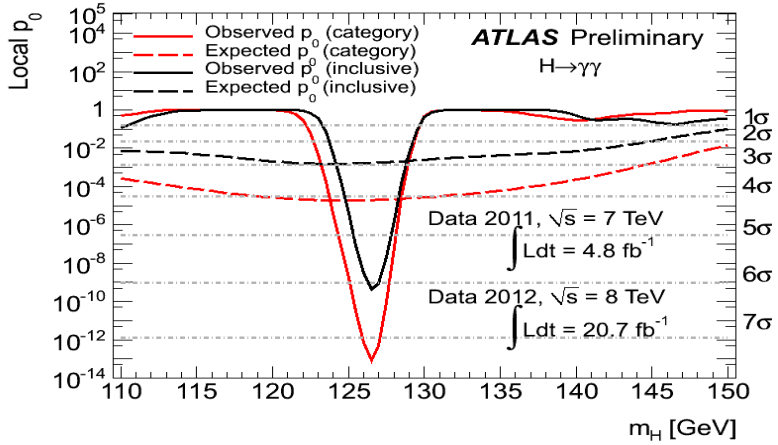


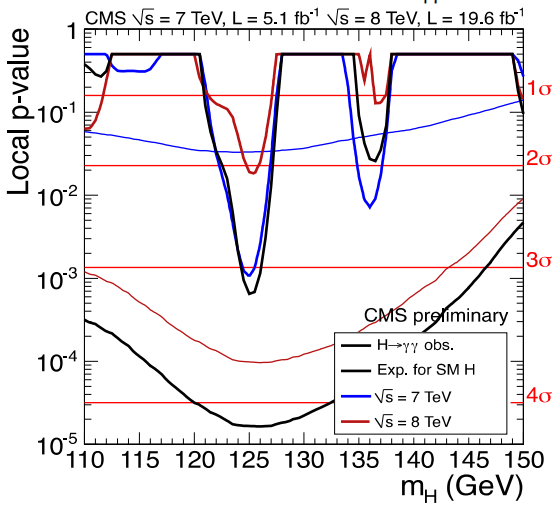
MVA

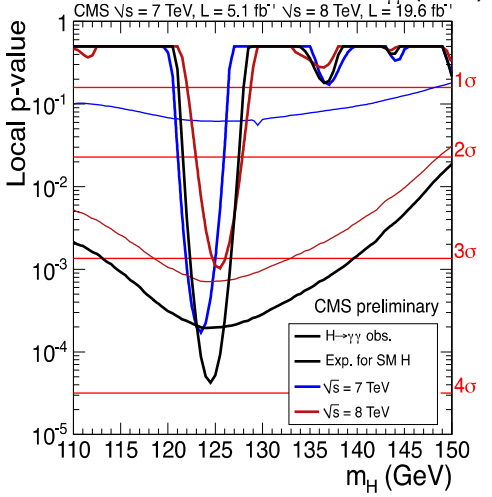


Cut Based









Significance @ 125.0 GeV: 3.2 σ (4.2 exp.)

Significance @ 124.5 GeV: 3.9 σ (3.5 exp.)

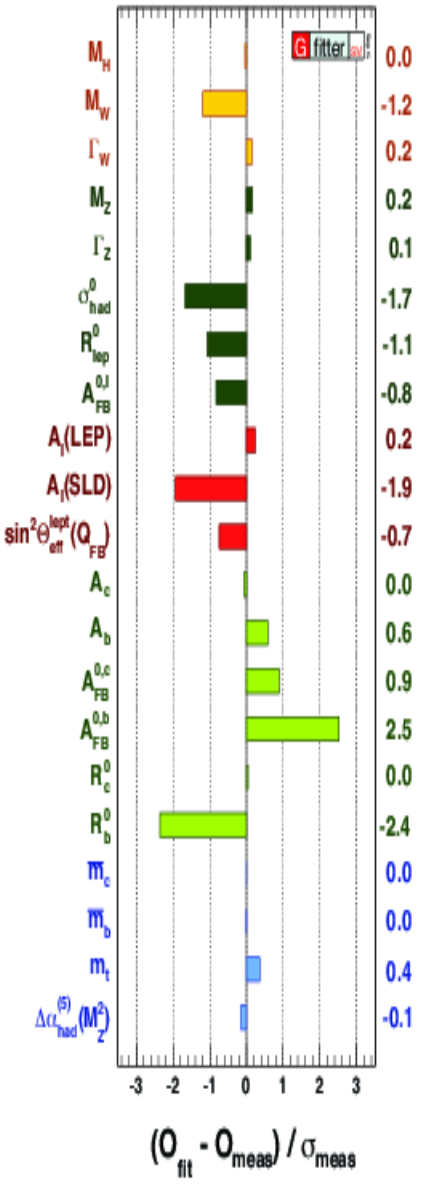
EWK Global Fits: Present and Future

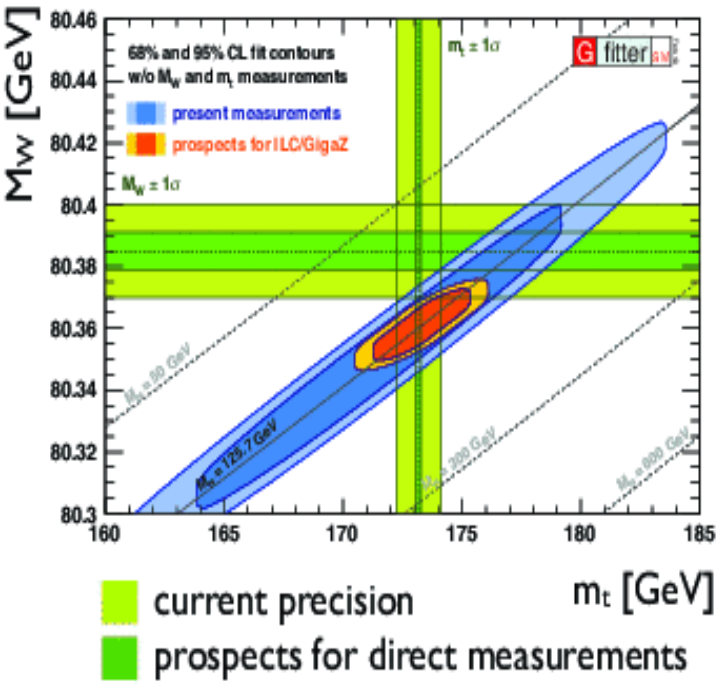
χ^2_{min}/ndf = 21.8/14 → p-value = 0.08

- large value of χ^2_{min} not due to inclusion of M_H measurement
- without M_H measurement:
  χ^2_{min} /ndf = 20.3/13 → naive p-value = 0.09

Pull values after the fit

- No pull value exceeds deviations of more than 3σ (consistency of SM)
- Small values for M_H, A_c, R^0_c, m_c and m_b indicate that their input accuracies exceed the fit requirements
- Largest deviations in the b-sector: $A^{0,b}_{FB}$ and R^0_b with 2.5σ and -2.4σ (little dependence on M_H)
- R^0_b using one-loop calculation: 0.8σ





- Assume 50% of today's theoretical uncertainty (implies three-loop EW calculations)
- Huge reduction of uncertainty for indirect determinations
- Strong constraints on S, T, U