Highlights from CMS physics results

. . . with a Naples bias

Luca Lista

INFN - Napoli

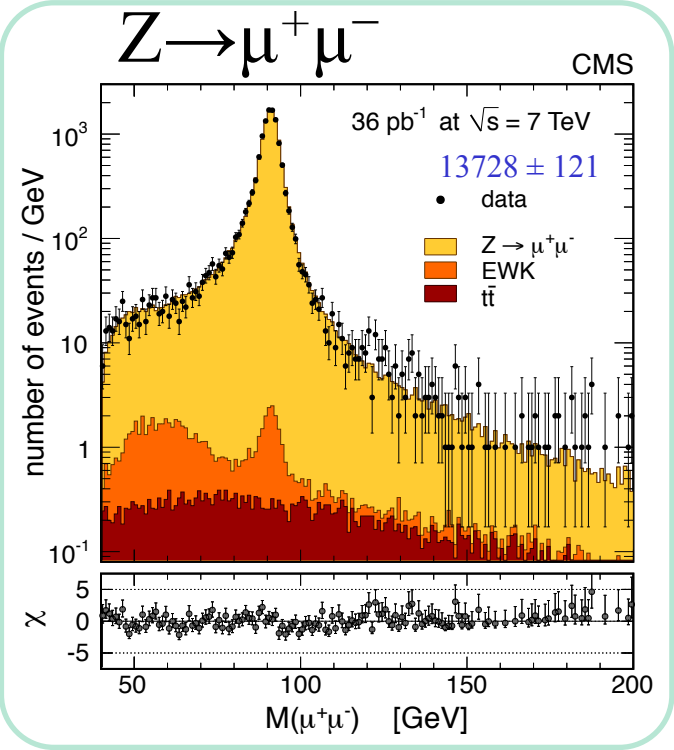
Group responsibilities

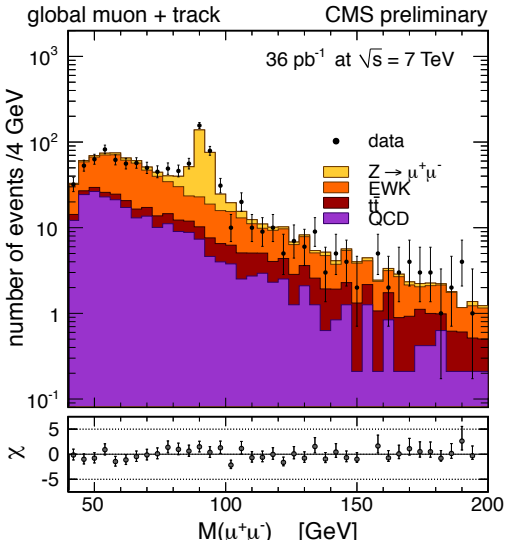
- Detector
  - Pigi: RPC Project Manager
  - Salvatore: RPC Technical Coordinator
  - Camilo: DPG convener (2012)
- Electroweak: Z incl. cross section, W/Z paper
  - Ended, JHEP published in October (Michele, Francesco, Annapaola, Luca)
- Single top
  - Orso, Mario, Luca, Oktay jumping in
  - Luca: new convener in 2012, member of TOPLHCWG
  - new postdoc in 2012
    - Orso and Mario will compete next year!
- Higgs: H→ZZ→2l2q
  - Annapaola, Francesco, Sabino
- Exotica: Heavy Charged Stable Particles
  - Camilo
- Statistics tools, PAT: Annapaola
- Statistics committee: Luca, Conferene committee: Pigi

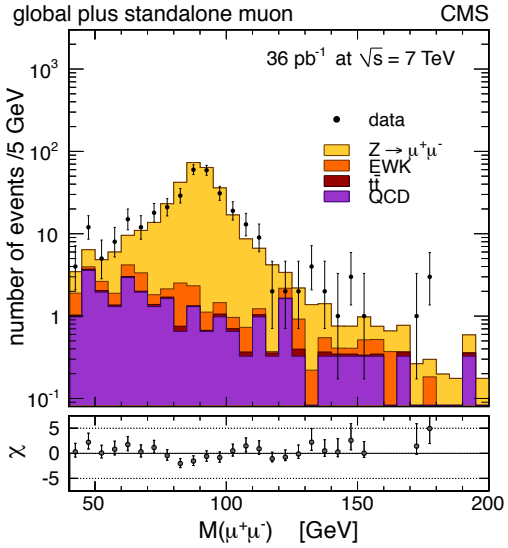
Electroweak Physics

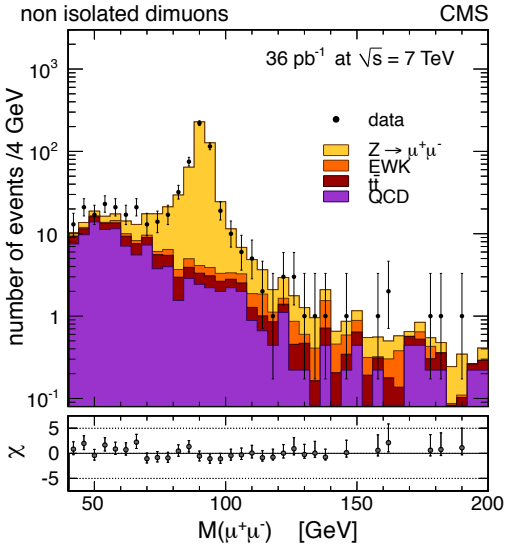
$Z \rightarrow ll$ inclusive cross section

- Isolated dilepton pairs with p_T>20 (μ), 25 GeV (e) and η within trigger fiducial region. Mass range: $60 < m_{ll} < 120$ GeV
- Fit simultaneously yield and efficiencies using different dilepton categories (μμ)
- Cut and count analysis using tag & probe efficiencies (ee)









W^+ and W^- production

- W production is charge asymmetric at LHC
  - Asymmetry is ~1.4, not 2, due to sea quark contribution
- All analysis ingredients are data driven
- Fit separately positive and negative lepton missing E_T spectra to extract $\sigma(W^+)$ and $\sigma(W^-)$
- Alternatively, fit simultaneously the total yield and ratio to extract $\sigma(W^\pm)$ and $\sigma(W^+)/\sigma(W^-)$
- In the ratio several uncertainties cancel

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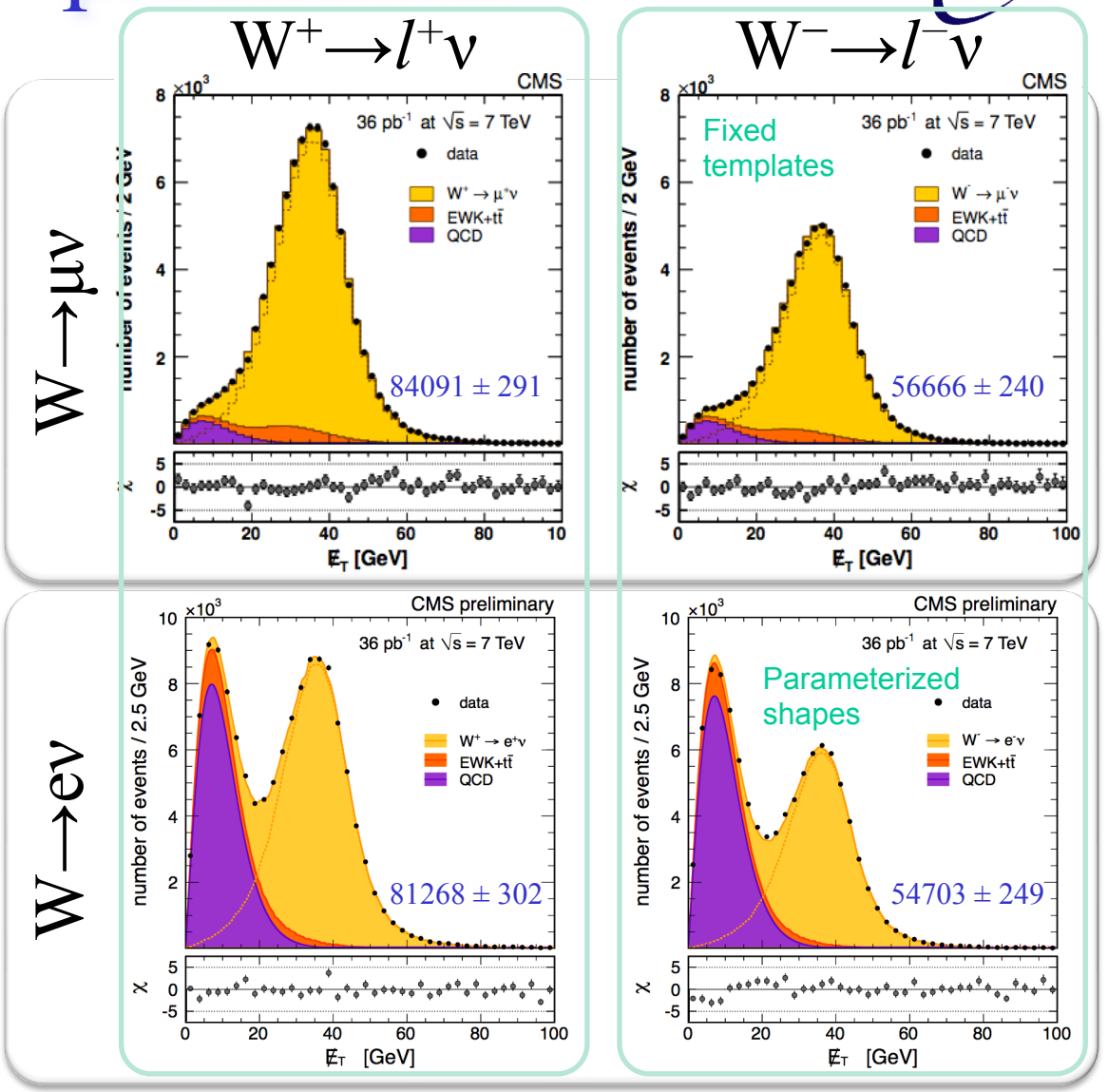
published end of Oct.



Systematic uncertainties

- Data-driven methods to determine efficiencies, background and signal shapes allow to reduce experimental uncertainties

$$\sigma \times \mathcal{B} = \frac{N}{A \times \varepsilon \times \mathcal{L}}$$

$$\rho = \frac{\varepsilon_{\text{data}}}{\varepsilon_{\text{sim}}}$$

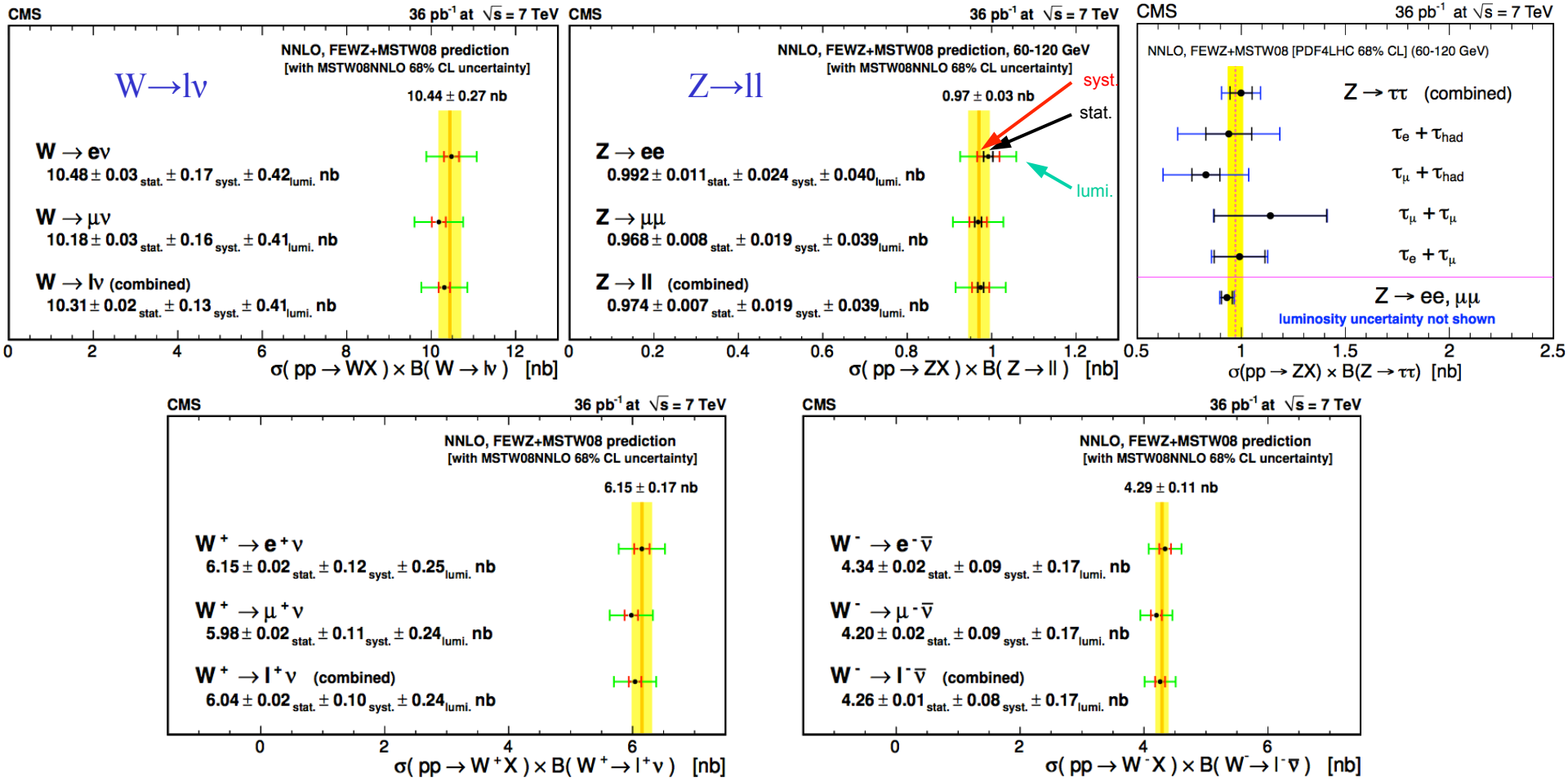
Uncert. propagated from Z T&P to W p_T/η spectrum

Lumi. uncert.: 4%

CMS-DP-2011-002

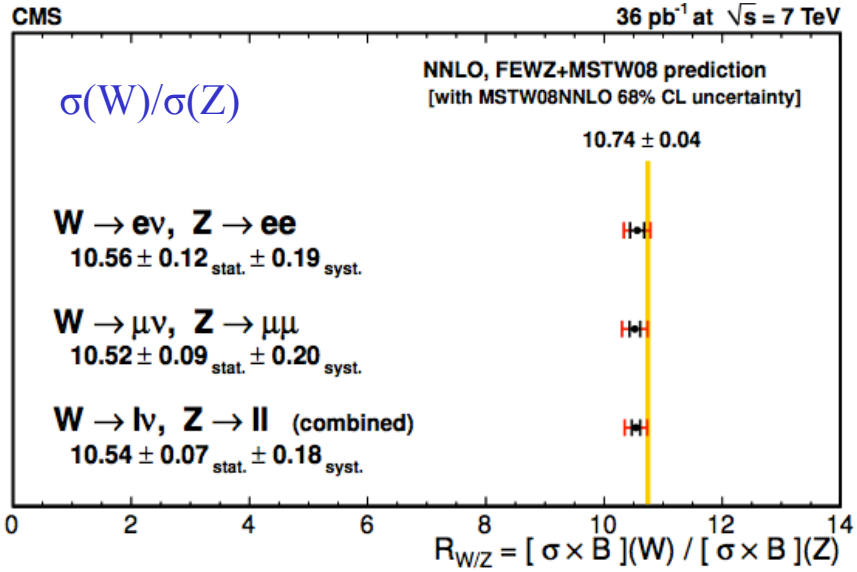
Source	$W \to e\nu$	$W \to \mu\nu$	$Z \to e^+e^-$	$Z \to \mu^+\mu^-$
Lepton reconstruction & identification	1.3	0.9	1.8	n/a
Trigger prefiring	n/a	0.5	n/a	0.5
Energy/momentum scale & resolution	0.5	0.22	0.12	0.35
$\not\!\!E_T$ scale & resolution	0.3	0.2	n/a	n/a
Background subtraction / modeling	0.35	0.4	0.14	0.28
Trigger changes throughout 2010	n/a	n/a	n/a	0.1
Total experimental	1.5	1.1	1.8	0.7
PDF uncertainty for acceptance	0.6	0.8	0.9	1.1
Other theoretical uncertainties	0.7	0.8	1.4	1.6
Total theoretical	0.9	1.1	1.6	1.9
Total (excluding luminosity)	1.7	1.6	2.4	2.0

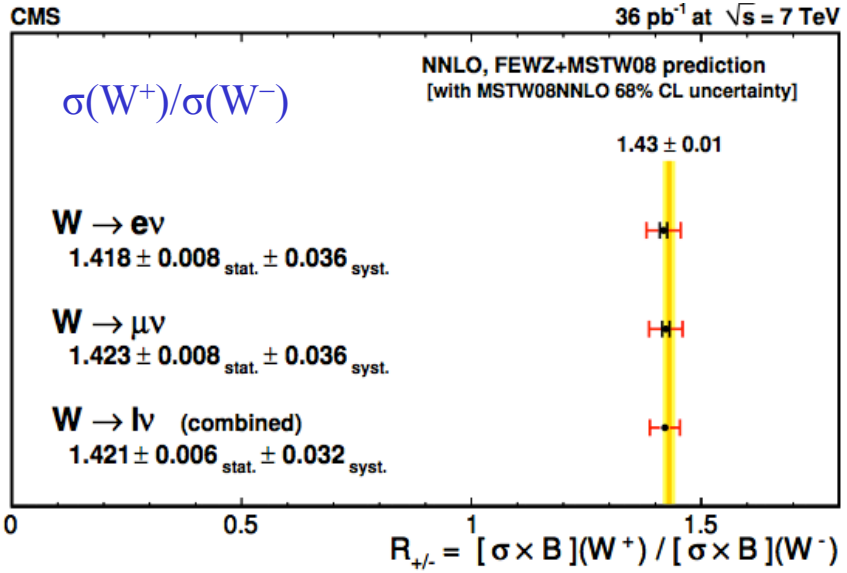
Comparison with theory



- Good agreement with theoretical predictions
- Systematic uncertainty dominates

Comparison with theory





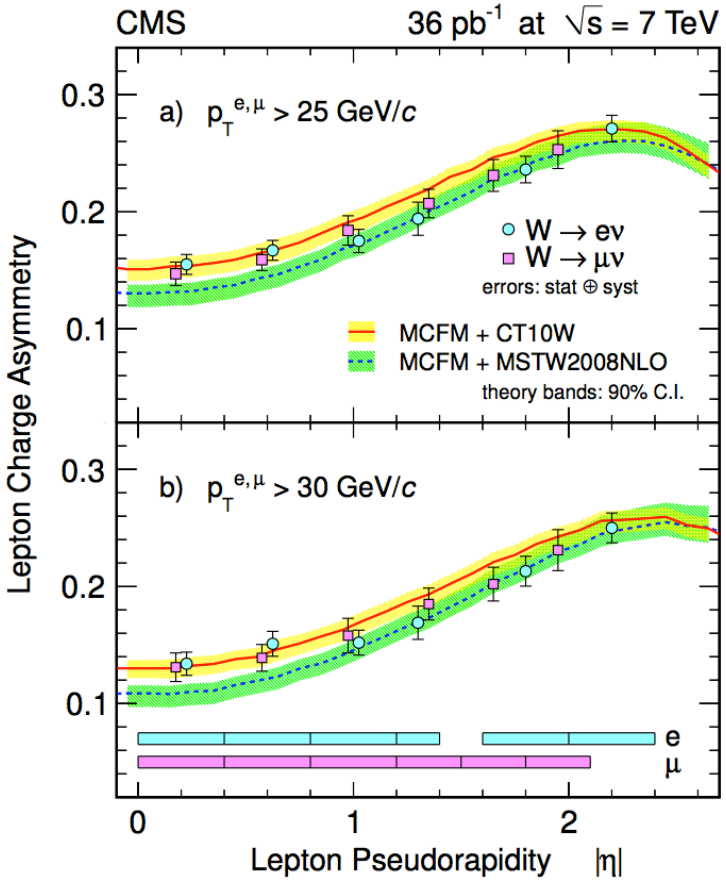
- Ratios are not affected by luminosity uncertainty
- W^+/W^- potentially sensitive to PDF, W/Z has precise prediction

W charge asymmetry

- W^+/W^- charge asymmetry vs η measured for both e and μ with $36pb^{-1}$
- Updated with $234pb^{-1}$ with muons only

$$\mathcal{A}(\eta) = \frac{d\sigma/d\eta(W^+ \to \ell^+\nu) - d\sigma/d\eta(W^- \to \ell^-\bar{\nu})}{d\sigma/d\eta(W^+ \to \ell^+\nu) + d\sigma/d\eta(W^- \to \ell^-\bar{\nu})}$$

- Similar selection to inclusive cross section analysis
- Signal yield from isolation variable fit (shape independent on η)
- Two p_T thresholds (25, 30 GeV) to probe different phase space regions
- Charge mis-id: 0.1(barrel)-0.4(endcap)% for electrons, $<10^{-4}$ for muons
- Statistical uncertainty: ~3%
- Systematic uncertainties (~3%), limited by the size of Drell-Yan control samples
  - Separate efficiency estimates for + and − leptons
  - p_T scale and resolution
  - Background and signal modeling



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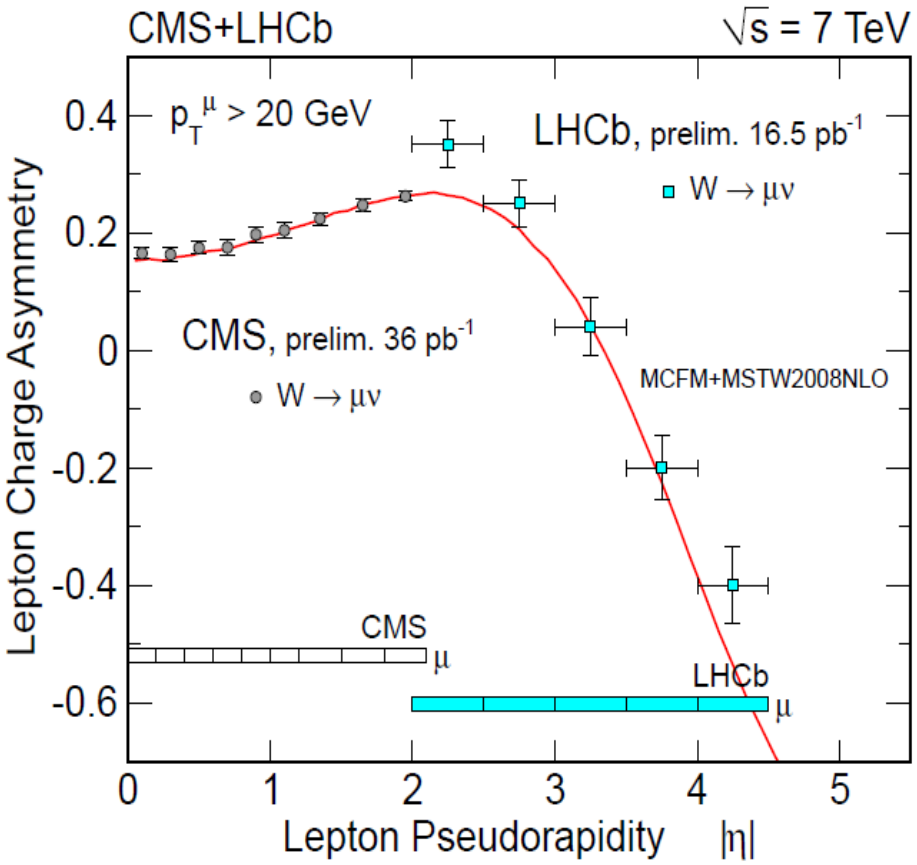
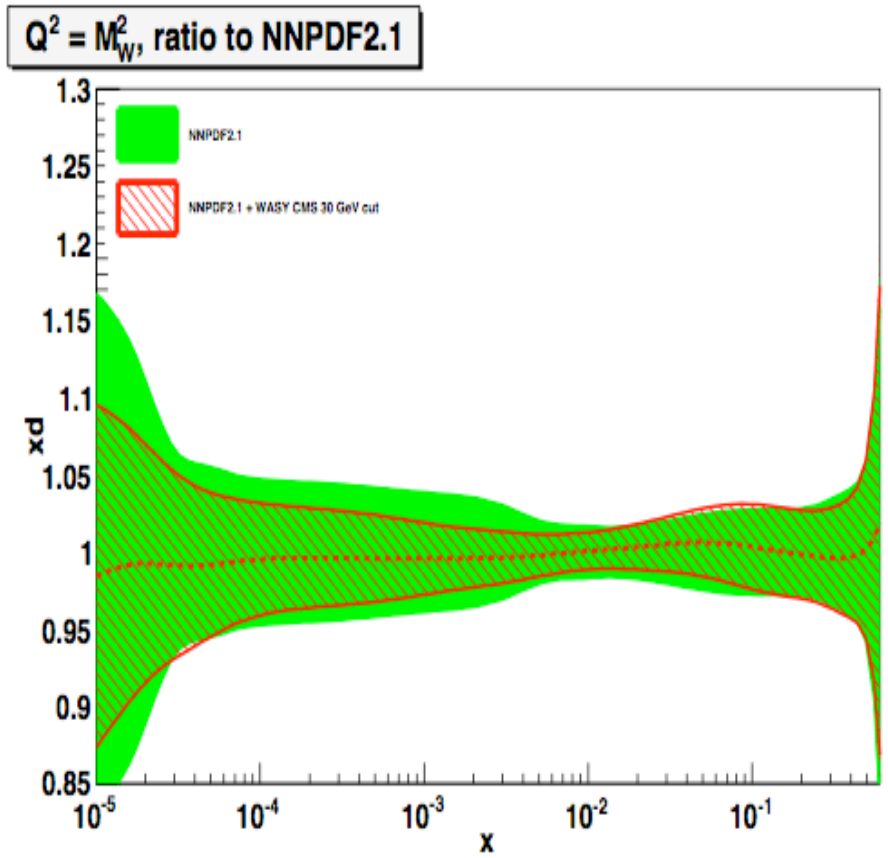
CMS ad LHCb measurements



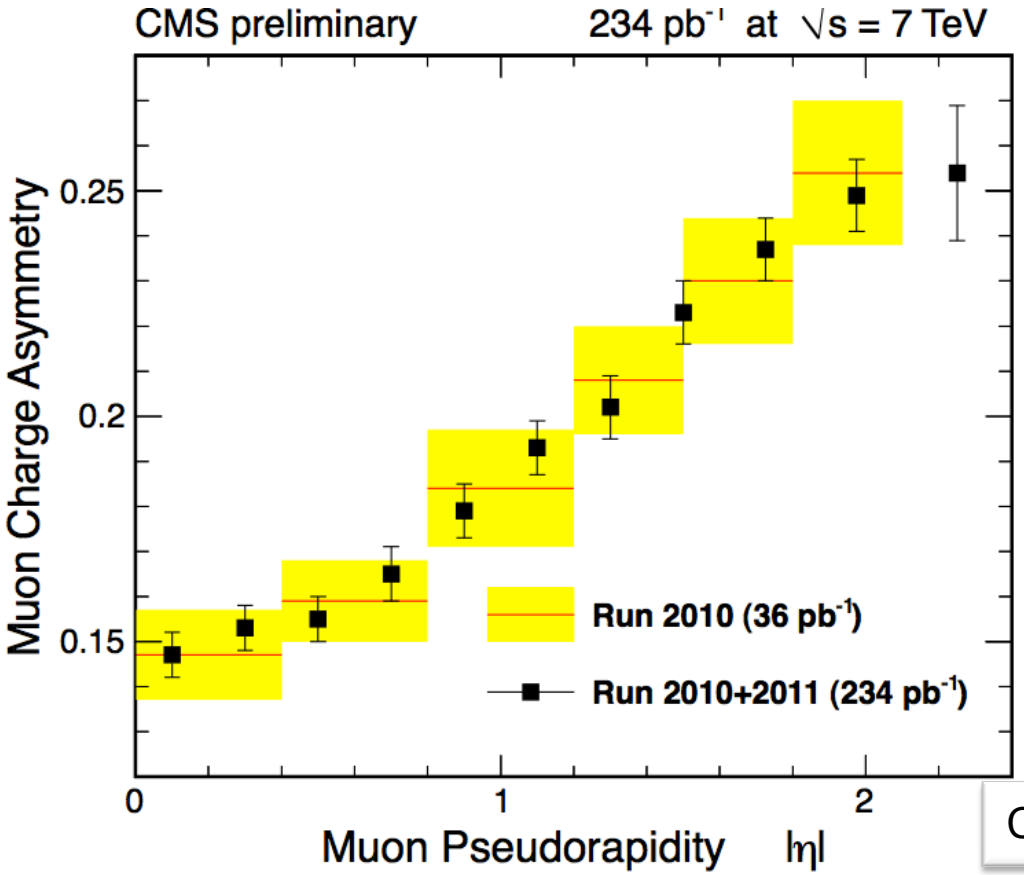
CMS complementary w.r.t. LHCb



CMS results already improve d,u,d,u,s quark PDFs by >40% in the range $10^{-3} < x < 10^{-2}$!!!

Asym. with 234 pb^{-1} (muons)

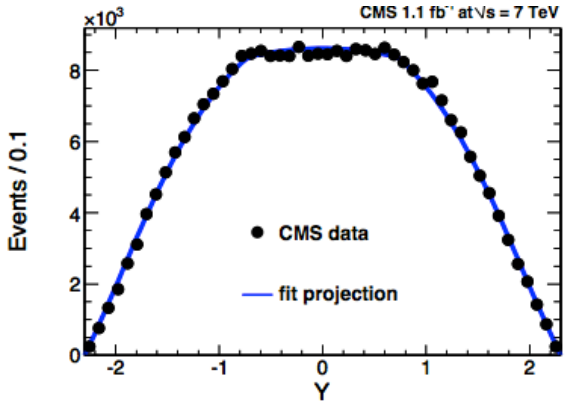
- Improved uncertainties with larger statistics and control samples
- Largest uncertainties: DY contamination (MC estimate), eff. (+/−) ratio, muon p_T scale

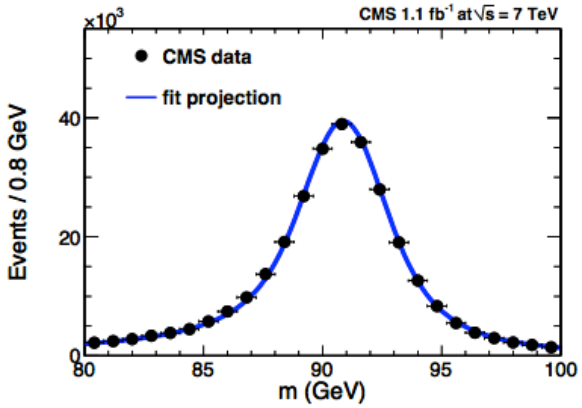


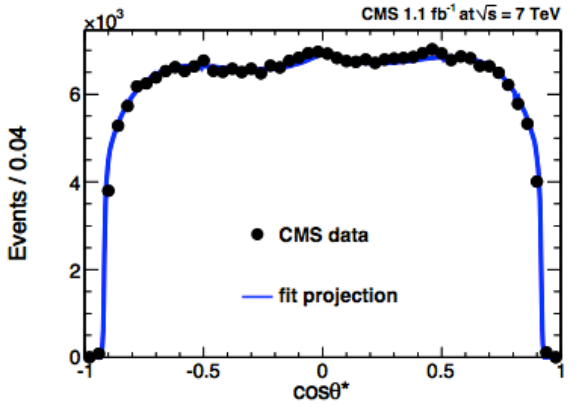
$\|\eta\|$ bin	$\mathcal{A} \pm$ stat $\pm$ sys
[0.00, 0.20]	14.7±0.32±0.41
[0.20, 0.40]	15.3±0.33±0.43
[0.40, 0.60]	15.5±0.32±0.44
[0.60, 0.80]	16.5±0.32±0.46
[0.80, 1.00]	17.9±0.34±0.50
[1.00, 1.20]	19.3±0.34±0.54
[1.20, 1.40]	20.2±0.33±0.58
[1.40, 1.60]	22.3±0.34±0.63
[1.60, 1.85]	23.7±0.31±0.64
[1.85, 2.10]	24.9±0.32±0.70
[2.10, 2.40]	25.4±0.35±1.50

CMS PAS EWK-11-005

$\sin^2\theta_W$ measurement with $1.1\,\mathrm{fb}^{-1}$







- The full decay information, including cosθ*, Y and $s=m_{ll}^2$ of the dimuon pairs, used to determination $\sin^2\theta_W$ using a complete triple-differential fit model built
  - Collins-Soper frame adopted for cosθ*
- Potential fit extension to beyond-SM couplings
- LO prediction + CTEQ6 PDF used as signal fit model
- The following parton level diff. cross section has to be combined with proper PDF contributions:

$$\frac{\mathrm{d}\sigma_{\mathrm{pp}}}{\mathrm{d}Y\,\mathrm{d}s\,\mathrm{d}\cos\theta^*} \propto \sum_{q=udscb} F_{\mathrm{q\bar{q}}}(s,Y)\left[\hat{\sigma}^{\mathrm{even}}_{\mathrm{q\bar{q}}}(s,\cos^2\theta^*) + D_{\mathrm{q\bar{q}}}(s,Y)\hat{\sigma}^{\mathrm{odd}}_{\mathrm{q\bar{q}}}(s,\cos\theta^*)\right]$$

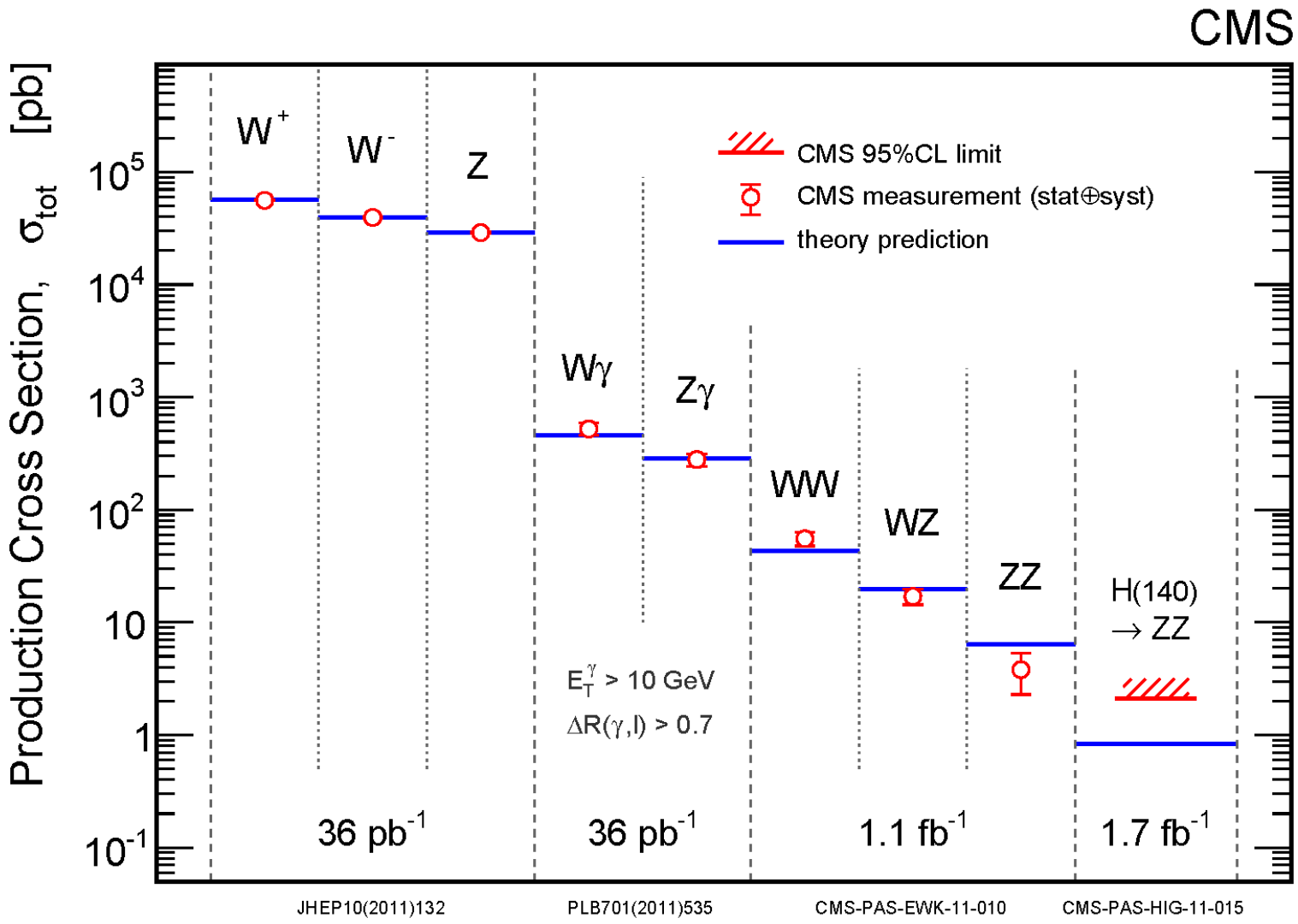
$$\hat{\sigma}_{\mathrm{q\bar{q}}}(s,\cos^2\theta^*) \propto \frac{3}{8}(1+\cos^2\theta^*) + A^{\mathrm{q\hat{q}}}_{FB}(s,\theta_W)\cos\theta^*$$

- Largest uncertainties: PDF, resolution and alignment, LO model (QCD), FSR

$$\sin^2\theta_{\mathrm{eff}} = 0.2287 \pm 0.0020\ (\mathrm{stat.}) \pm 0.0025\ (\mathrm{syst.})$$

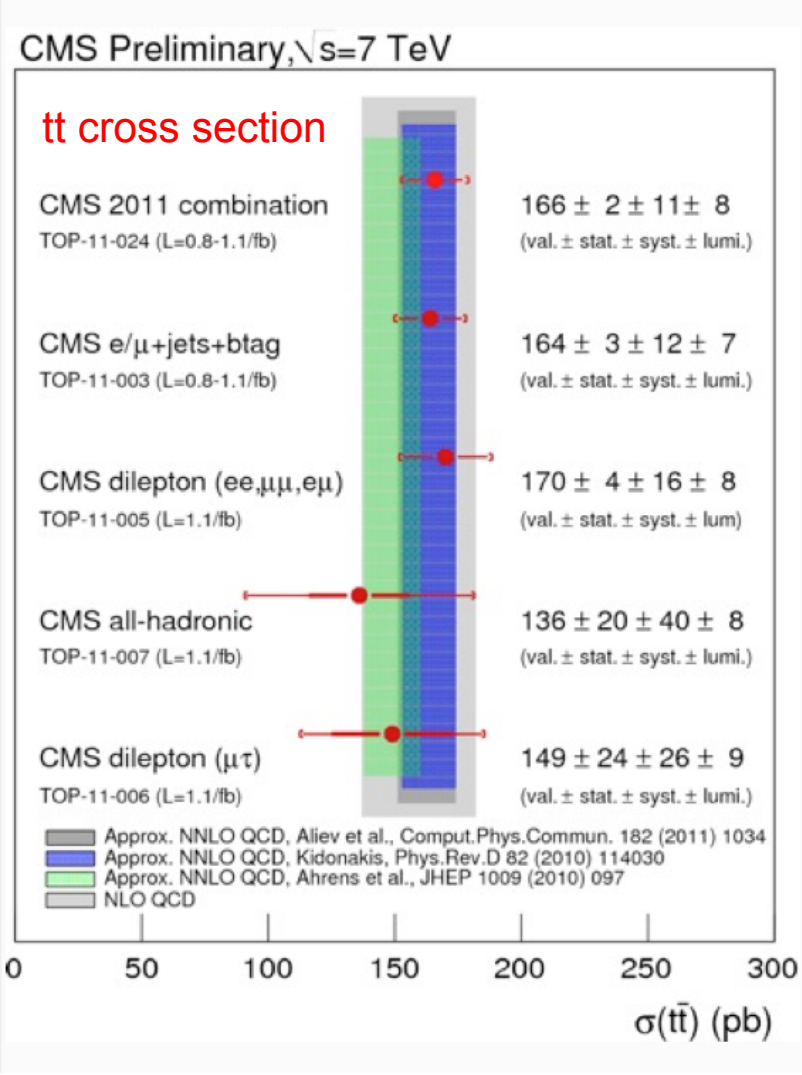
Phys. Rev. D 84, 112002 (2011)

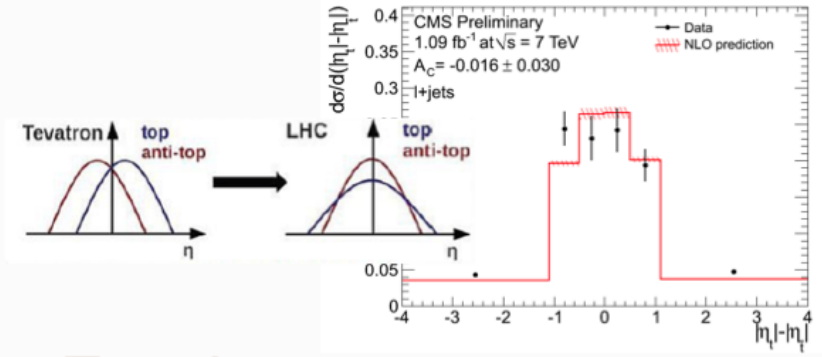
EWK summary


CMS
Production Cross Section, σ_{tot} [pb]
10^5
10^4
10^3
10^2
10
1
10^{-1}
W^+
W^-
Z
Wγ
Zγ
WW
WZ
ZZ
H(140) → ZZ
CMS 95%CL limit
CMS measurement (stat⊕syst)
theory prediction
E_T^γ > 10 GeV
ΔR(γ,l) > 0.7
36 pb^{-1}
36 pb^{-1}
1.1 fb^{-1}
1.7 fb^{-1}
JHEP10(2011)132
PLB701(2011)535
CMS-PAS-EWK-11-010
CMS-PAS-HIG-11-015

Top physics

Top quark properties





Top charge asymmetry

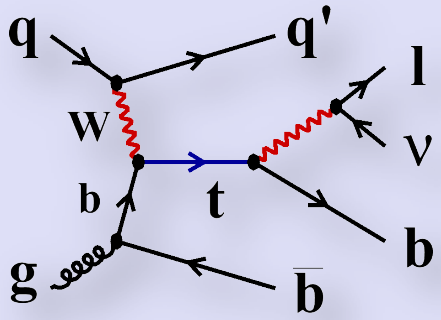
- $A_C = [N(\Delta>0) - N(\Delta<0)]/N_{tot}$
  $= -1.6 \pm 3.0(stat)\ ^{+1.0}_{-1.9}(syst)$ %
- A_C (theory) = 1.3%

t-tbar mass difference

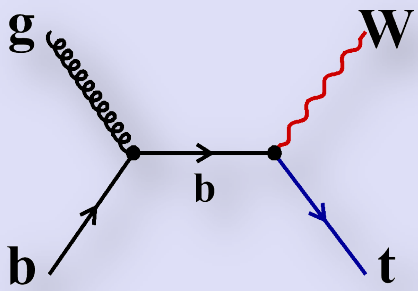
- Muon+jets channel
- Kinematic fit to the mass of the hadronically decaying top
- $\Delta m(t\text{-}tbar) = -1.20 \pm 1.21(stat) \pm 0.47(syst)$ GeV
- More accurate than Tevatron

Single top production

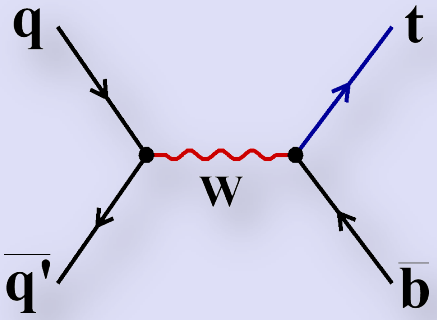
t-channel



associated Wt production



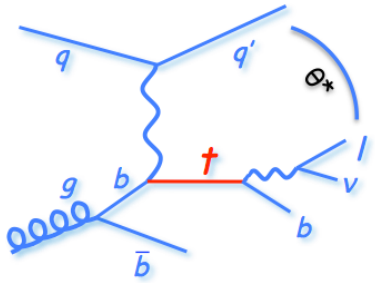
s-channel



Cross sections(pb) (top mass =173)	***s-channel*** Phys. Rev. D 81, 054028 (2010), N. Kidonakis	***tW channel*** Phys. Rev. D 82, 054018 (2010), N. Kidonakis	***t channel*** Phys. Rev. D 83, 091503(R) (2011) N. Kidonakis
LHC: *pp* @7 TeV	4.59	15.6	63.2
Tevatron *pp* @1.96 TeV	1.04	0.22 (arxiv.org/pdf/0909.0037)	2.08
LHC *pp* @14 TeV	11.9	83.6	243

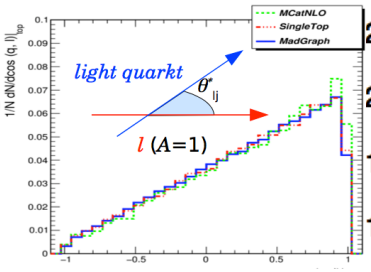
- Allows a $|V_{tb}|$ measurement
- Search for non-SM phenomena
  - Search W' or H+ (Wt or s-chan. signature)
  - Search for FCNC, e.g. ug → t

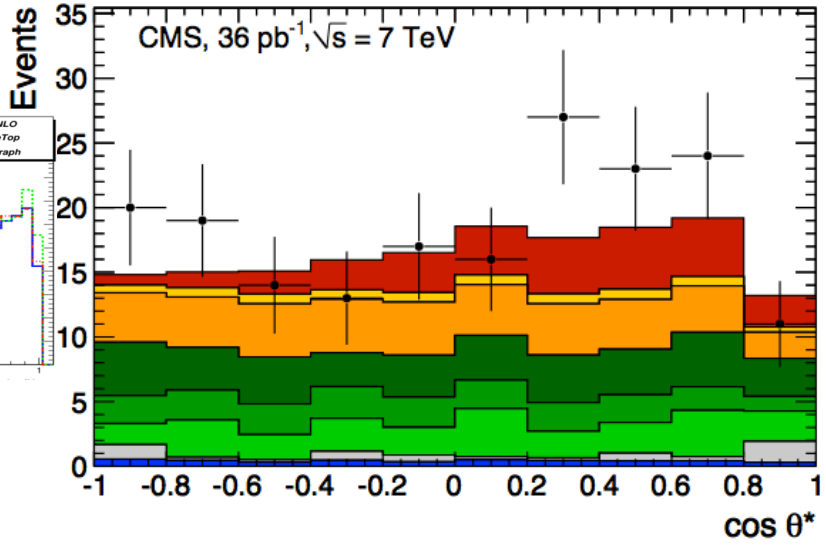
Background estimate from data

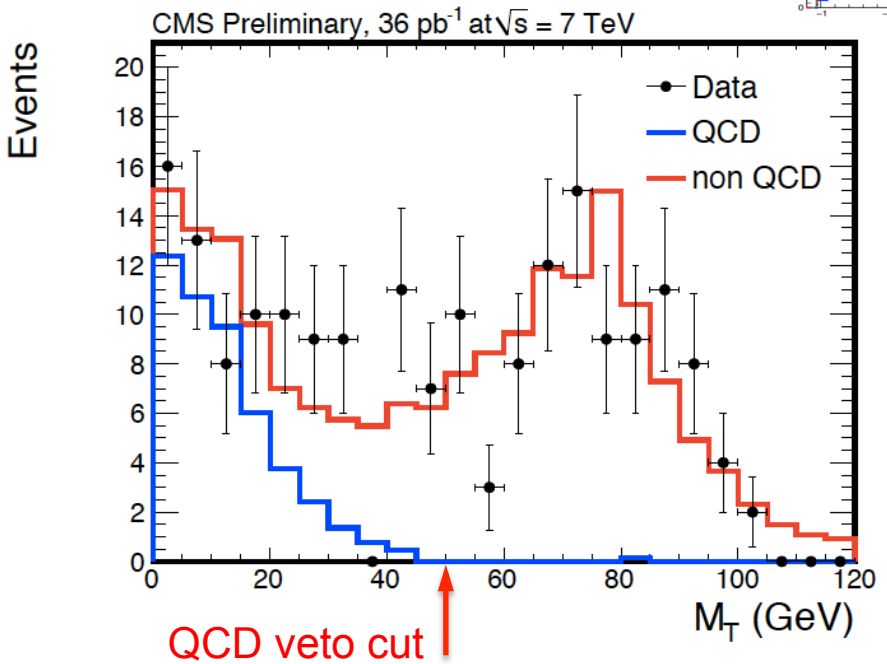


$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta^*} = \frac{1}{2}(1+\cos\theta^*)$$

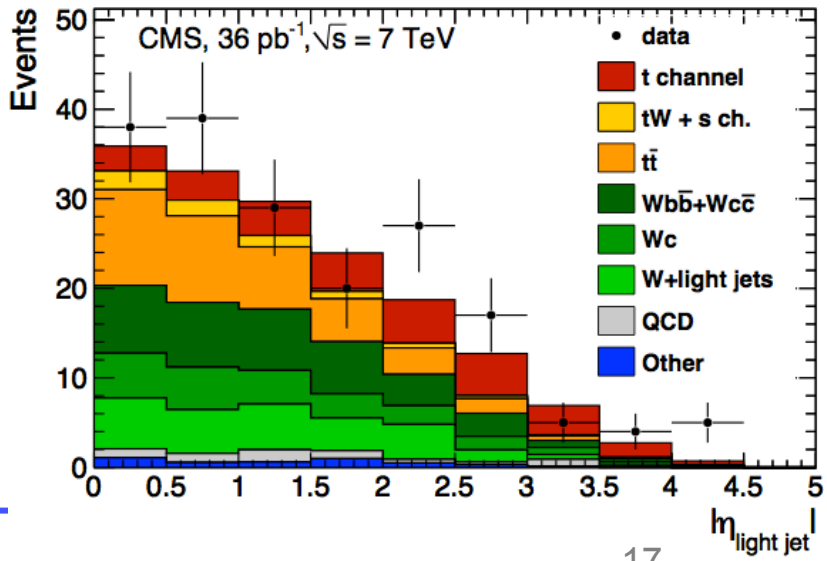
100% left (right) polarization of t(t̄)





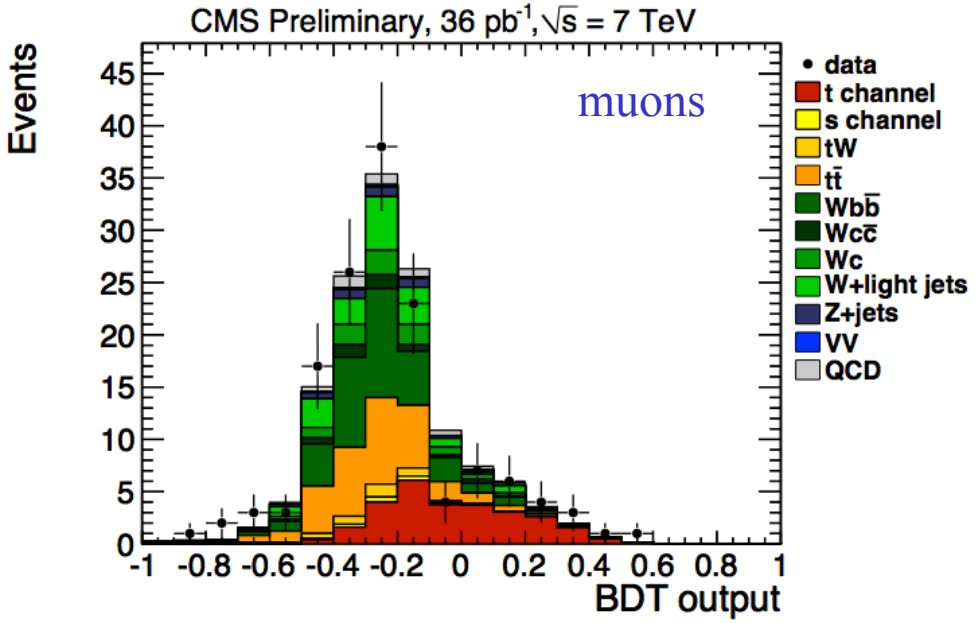


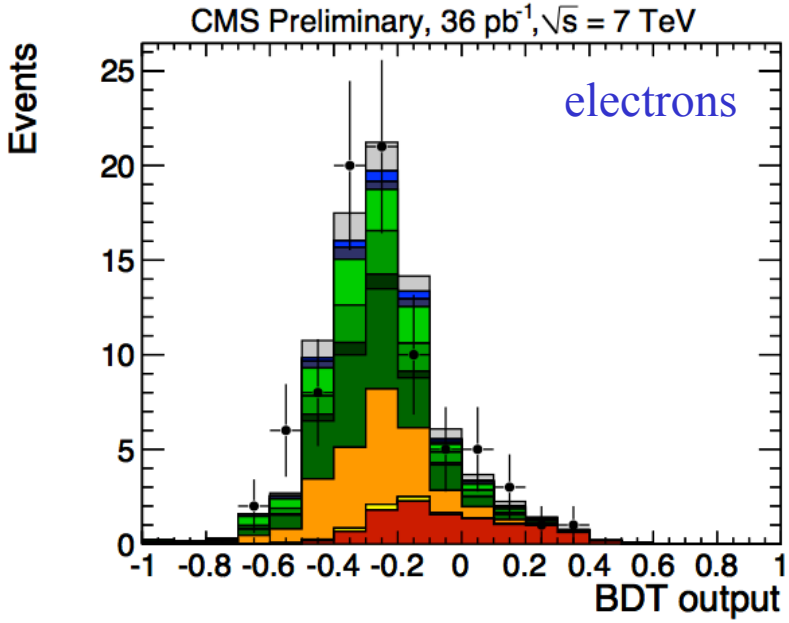
$$F(M_T) = N_{sig-like} \cdot S(M_T) + N_{qcd} \cdot B(M_T)$$



Signal extraction

- Complementary approaches adopted: Phys. Rev. Lett. 107 (2011) 091802
  - 2D maximum likelihood method ($\cos\theta^*$, $|\eta_{lq}|$)
  - Multivariate analysis (Boosted Decision Trees)





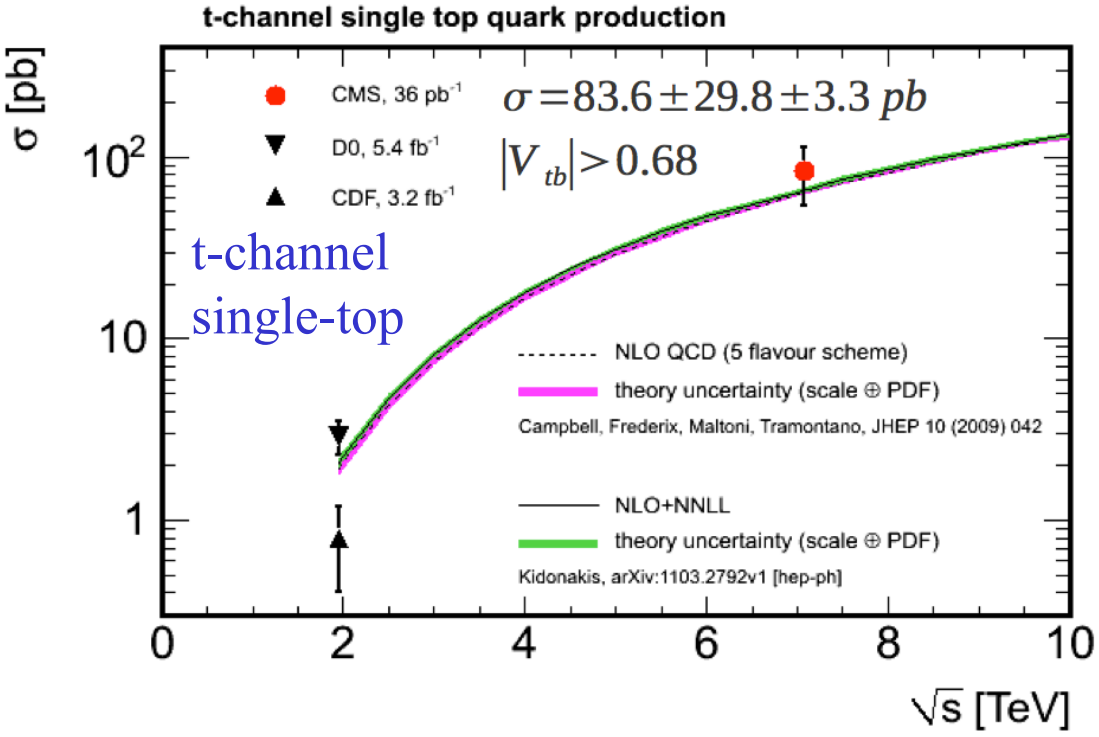
$$\sigma = 83.6 \pm 29.8(stat. + syst.) \pm 3.3(lumi.)\ \text{pb}$$

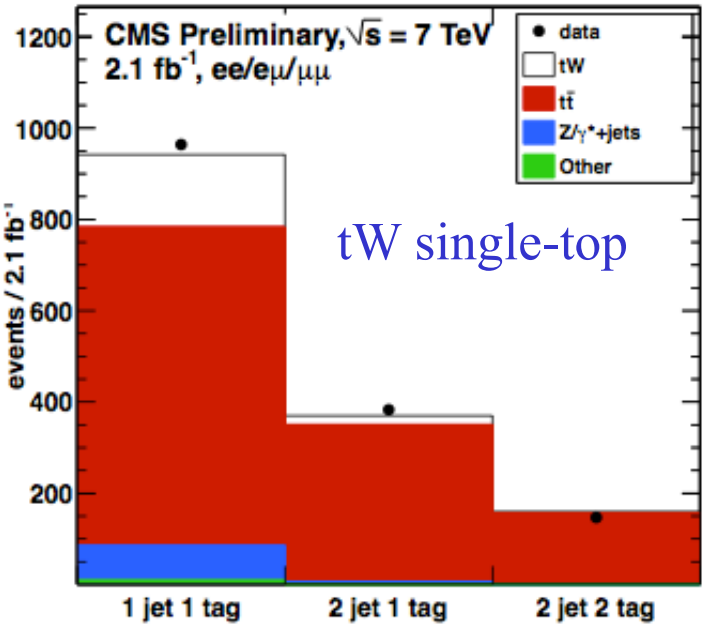
CMS (36pb^{-1}), update in progress!

$$|V_{tb}| = \sqrt{\frac{\sigma^{exp}}{\sigma^{th}}} = 1.16 \pm 0.22(exp) \pm 0.02(th)$$

Compare to: ATLAS (0.7fb^{-1}) : $\sigma_t = 90^{+32}_{-22}$ pb ATLAS-CONF-2011-101

Tevatron vs LHC



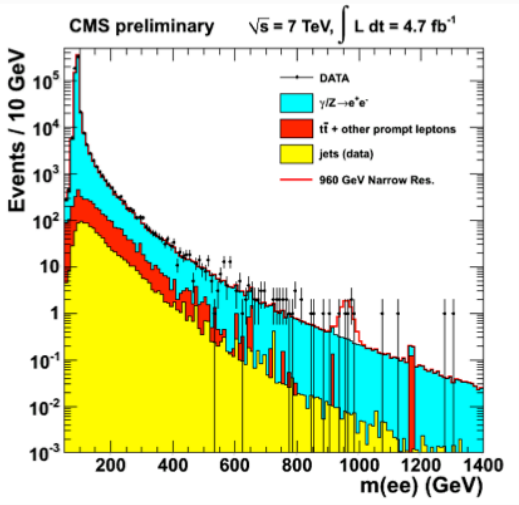


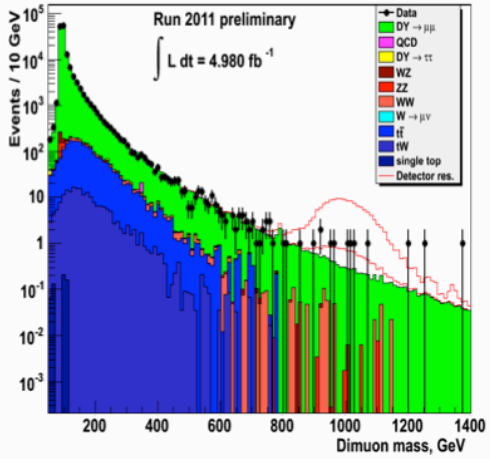
CMS PAS TOP-11-022

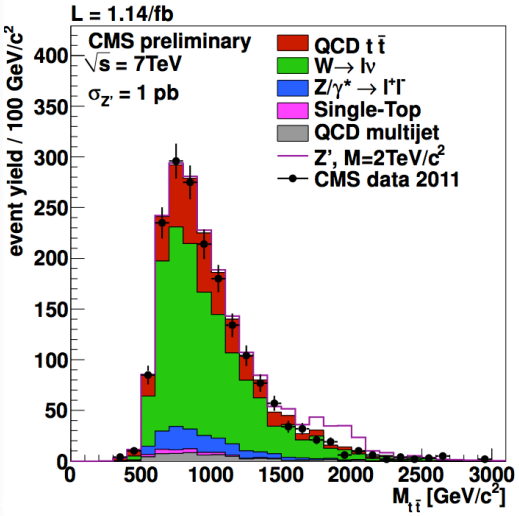
- $\sigma_{tW} = 22^{+9}_{-7}$pb (2.7σ significance), never measured at Tevatron
  - SM: $\sigma_{tW} = 15.6$pb
- s channel for next year (ATLAS limit: 5×SM so far…)

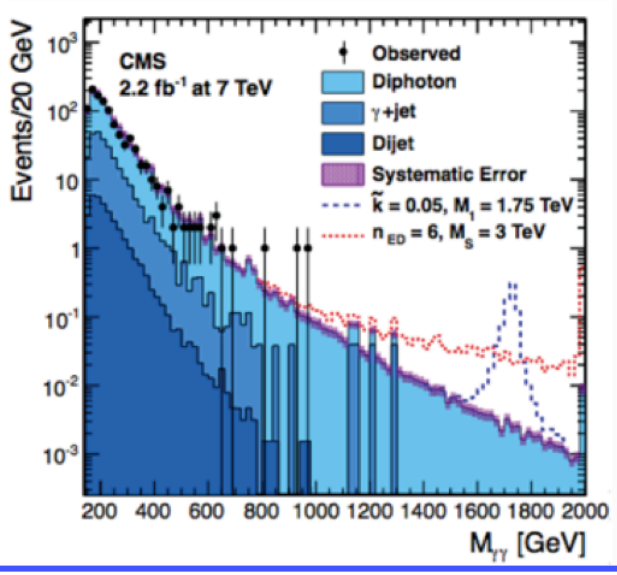
Searches for new Physics

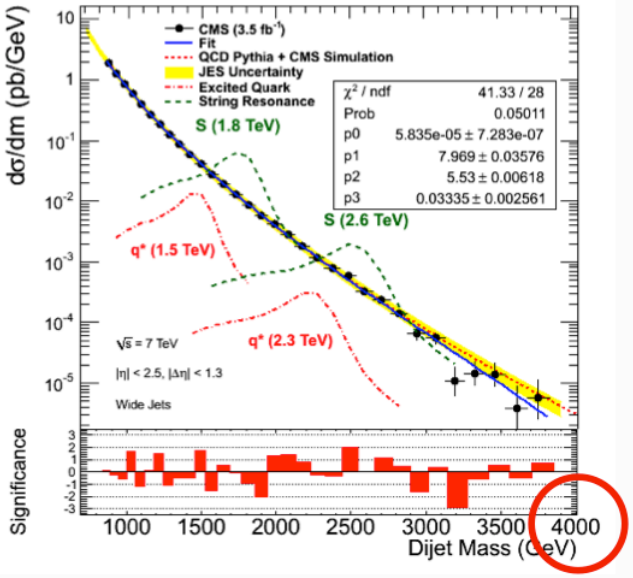
Heavy resonances



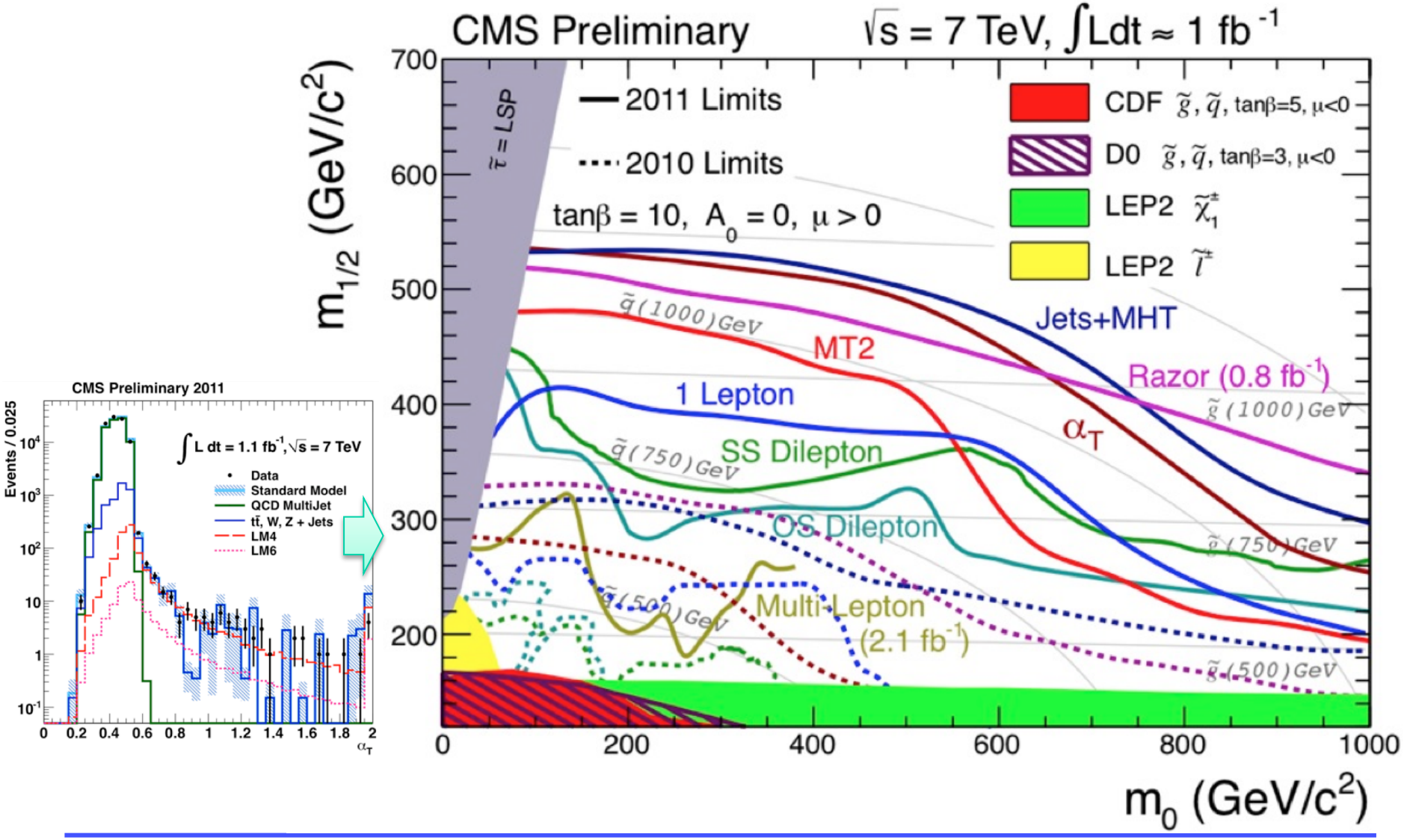




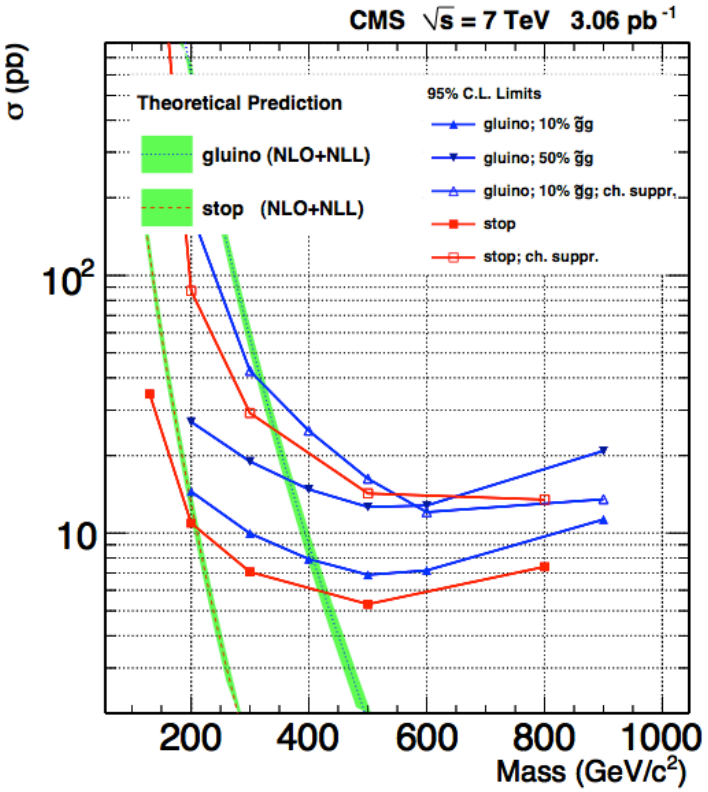




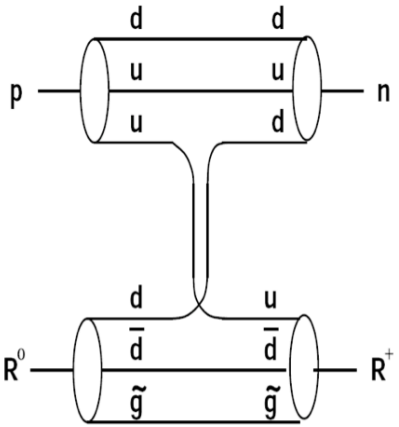
Super-Symmetry

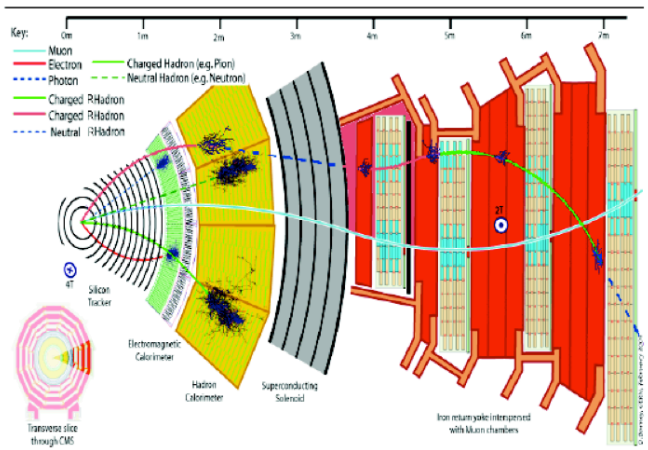


Heavy Stable Charged Particles



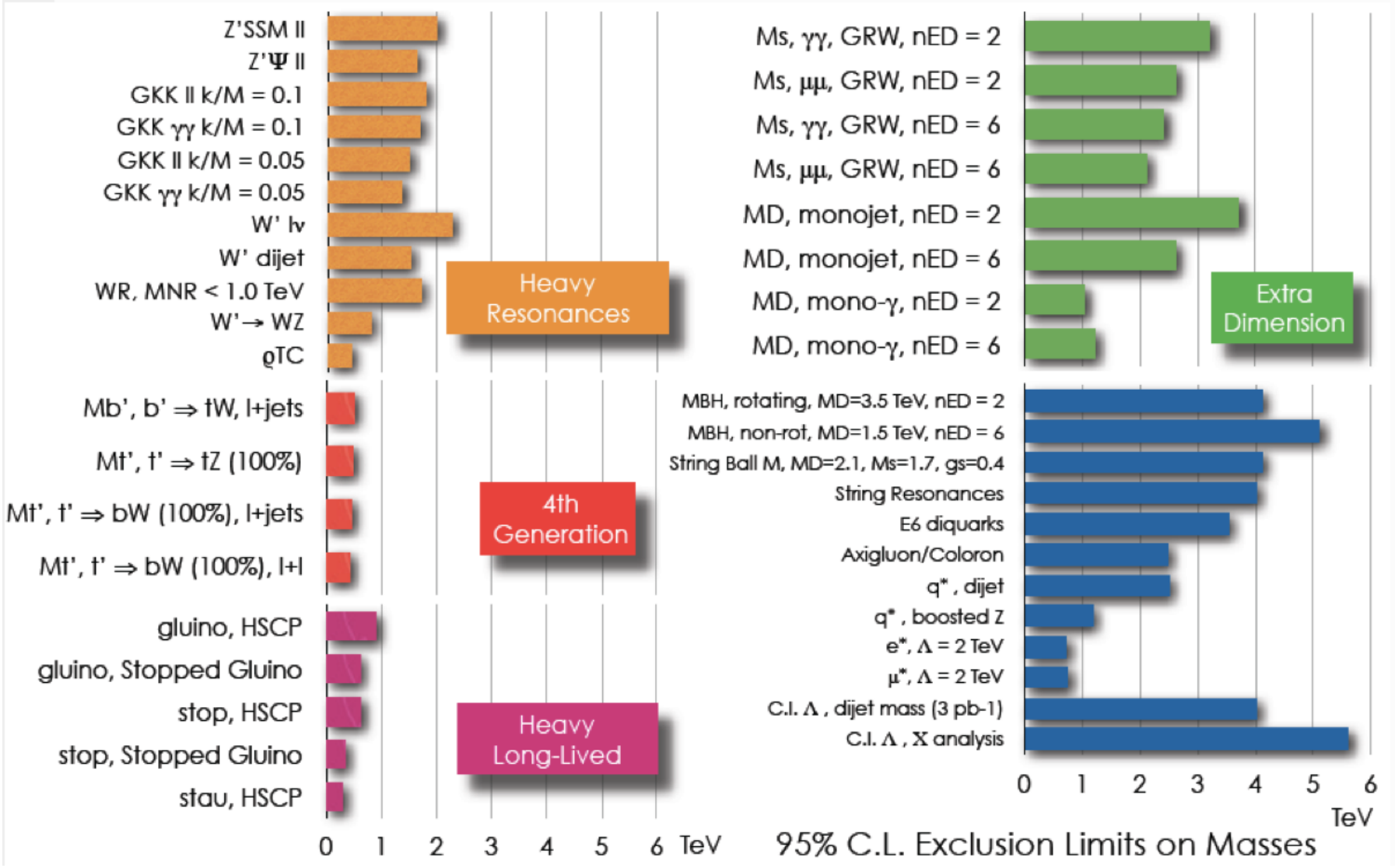
- May flip their charge while crossing the detector
- Significant effort for simulation of time response
- Update in progress with larger data samples





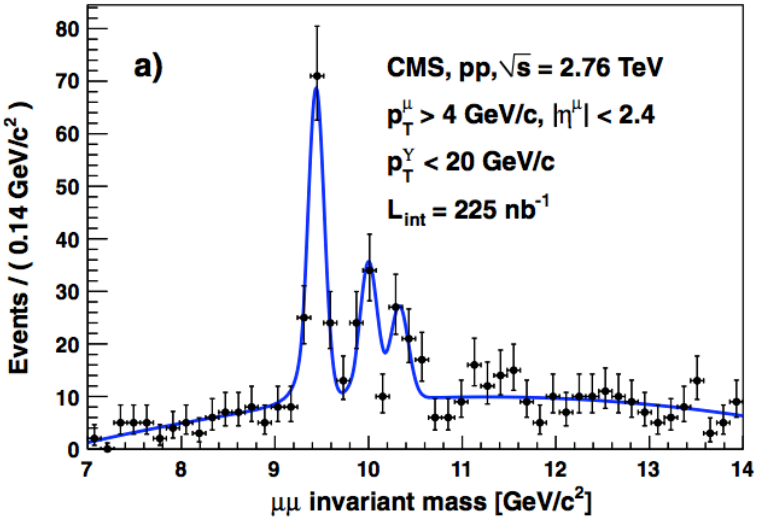
J. High Energy Phys. 03 (2011) 024

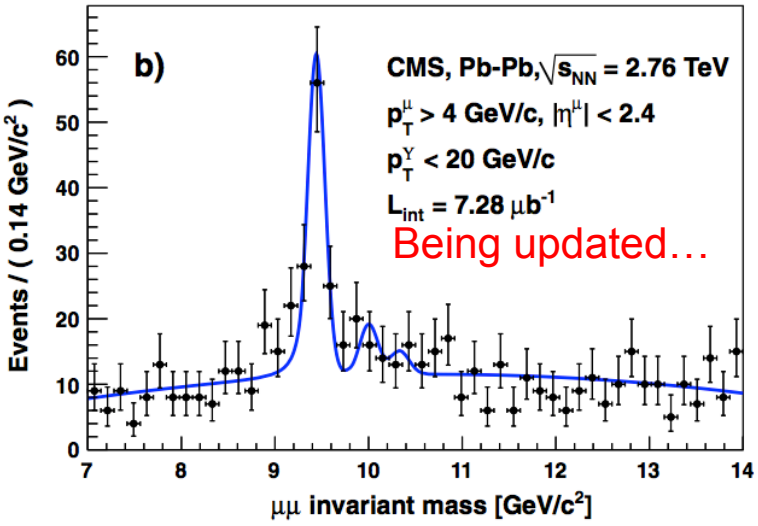
Exotica searches

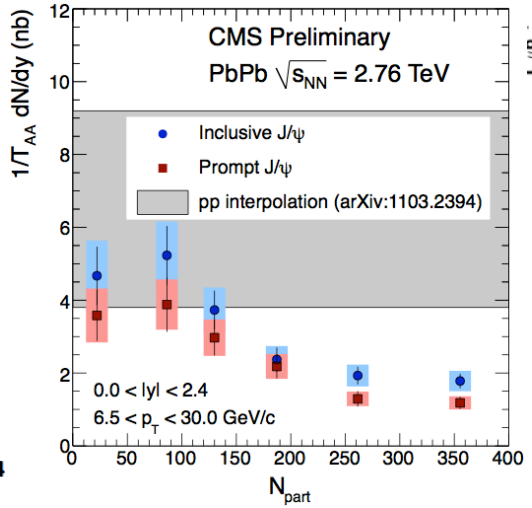


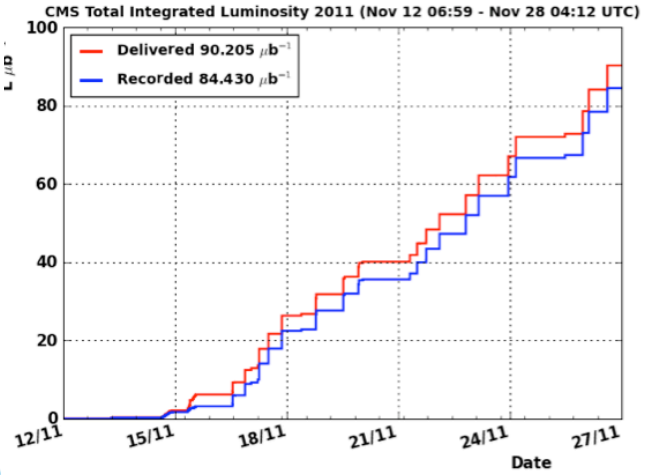
Heavy ions

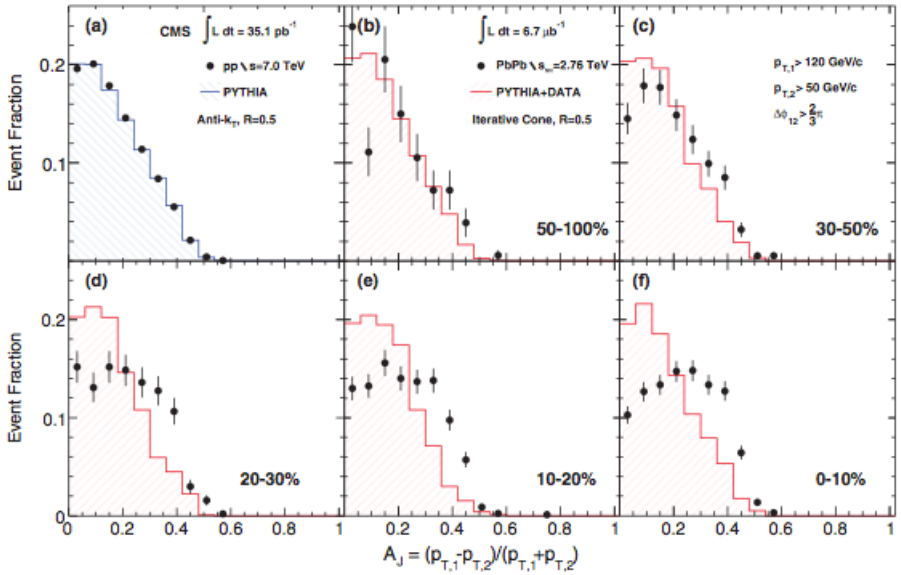
Heavy ions results





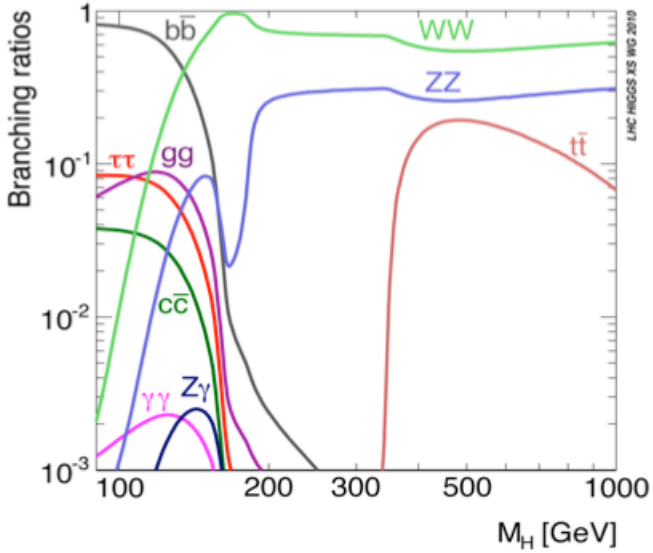


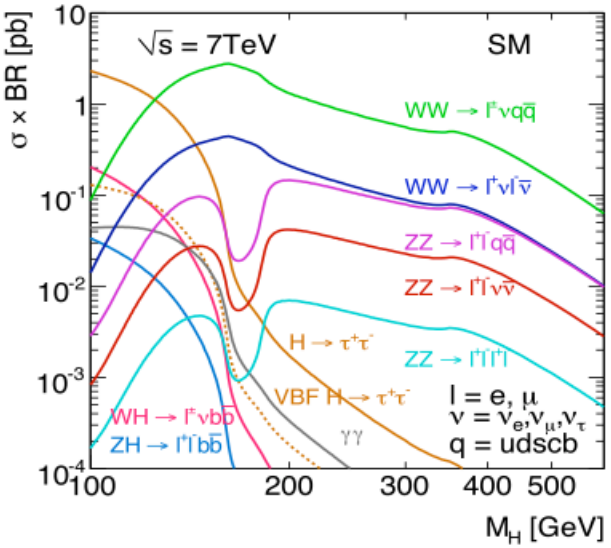




Search for the SM Higgs boson

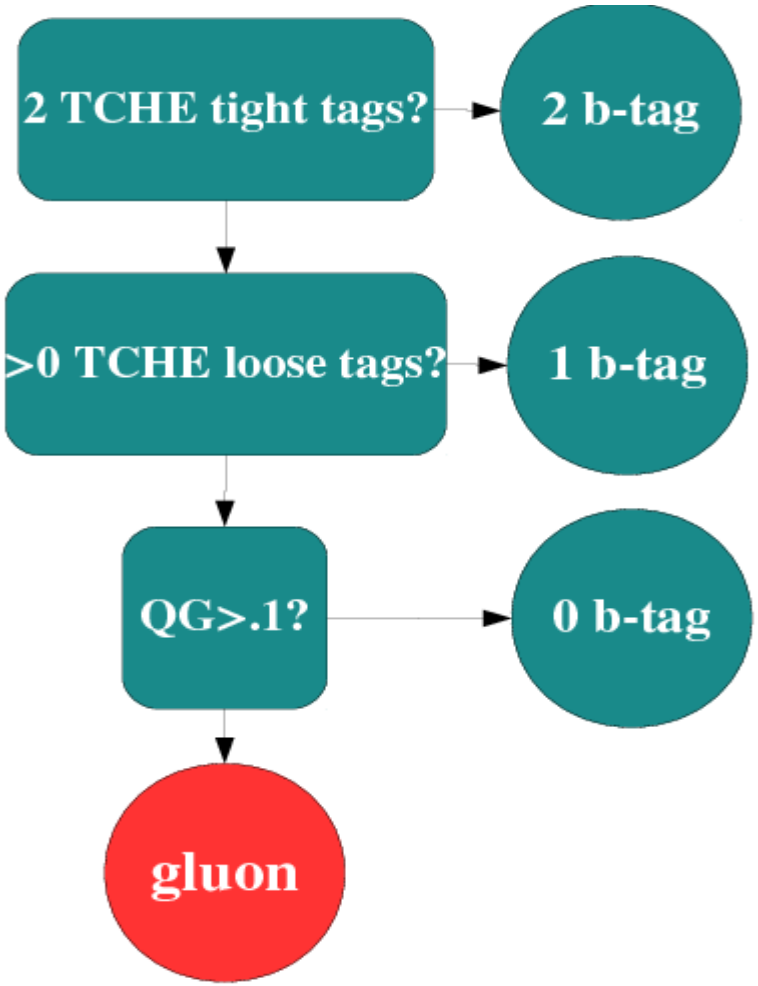
Higgs search channels

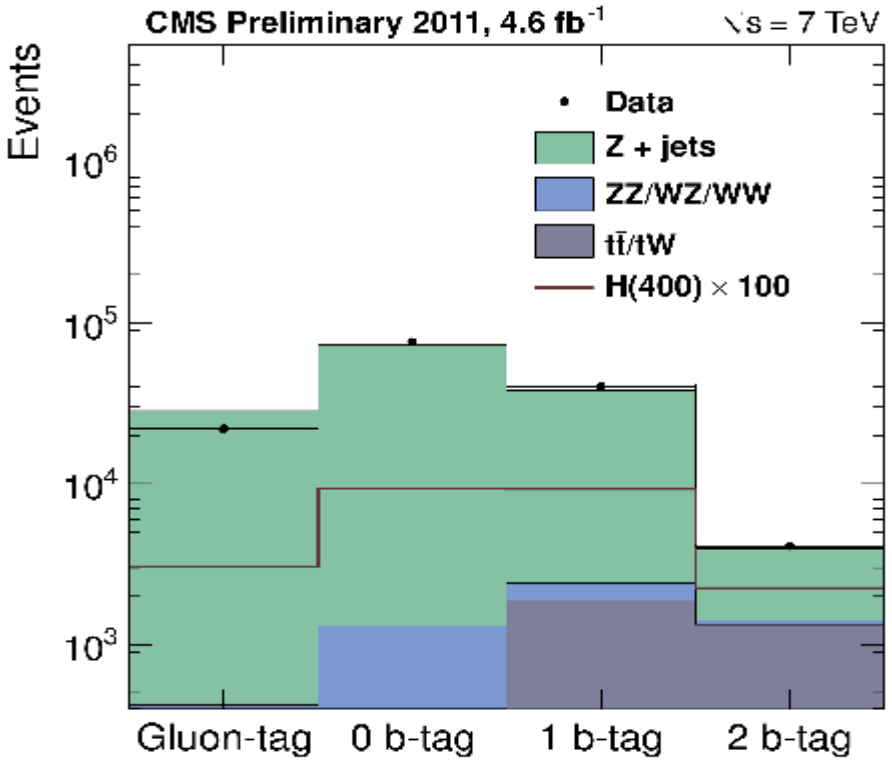




Mode	Mass Range	Data Used (fb^{-1})	CMS Document
H → γγ	110-150	4.7	HIG-11-030
H → bb	110-135	4.7	HIG-11-031
H → ττ	110-145	4.6	HIG-11-029
H →WW →2l 2ν	110-600	4.6	HIG-11-024
H → ZZ →4l	110-600	4.7	HIG-11-025
H → ZZ →2l2τ	190-600	4.7	HIG-11-028
H → ZZ →2l2j	130-165/200-600	4.6	HIG-11-027
H → ZZ →2l2ν	250-600	4.6	HIG-11-026

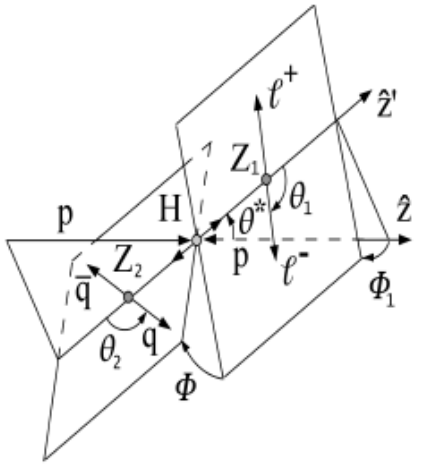
H→ZZ→2l2j strategy

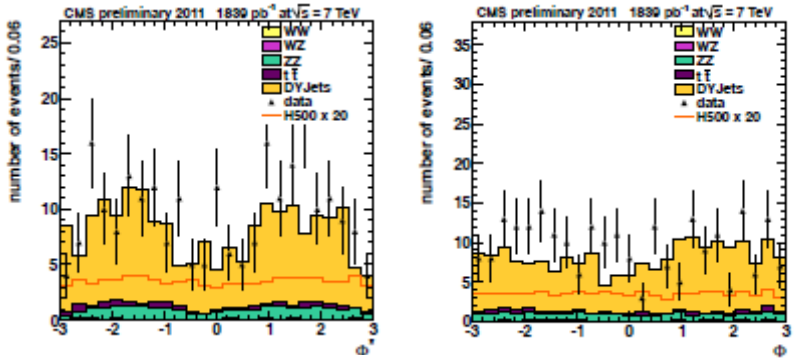


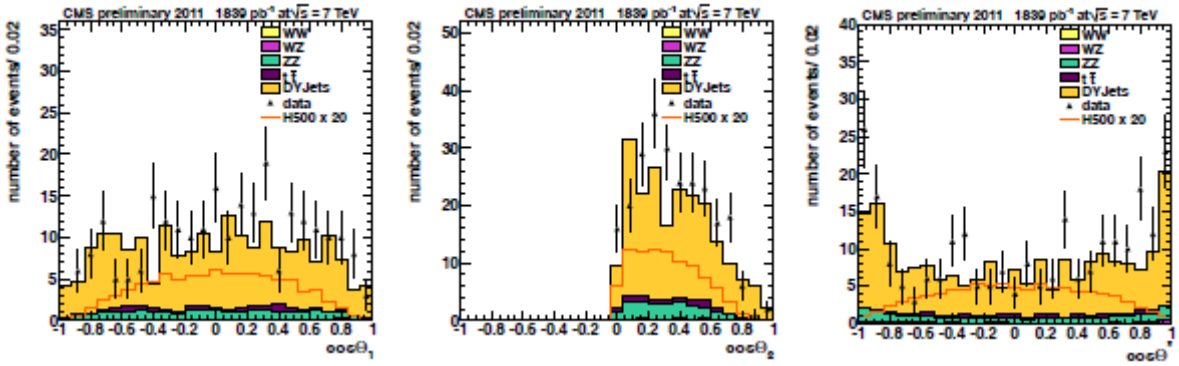


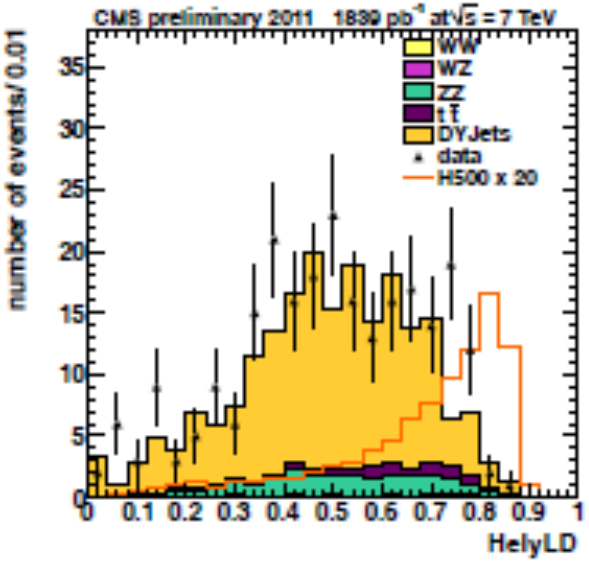
Angular Discriminant

- Kinematics of the event described univocally by 5 helicity angles, combined in a LD.
- Exploit spin info which is manifest in angular correlations.
- Cut on LD is a function of diboson reconstructed mass and depend on the btag category.

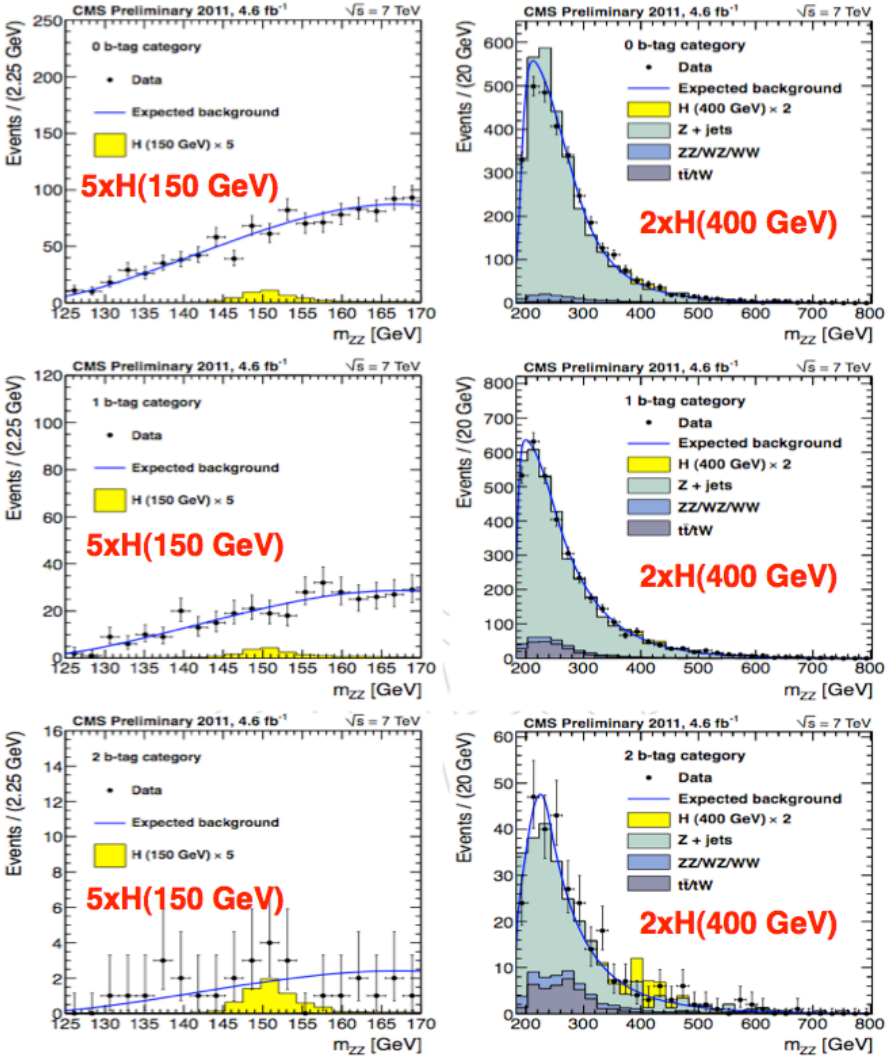


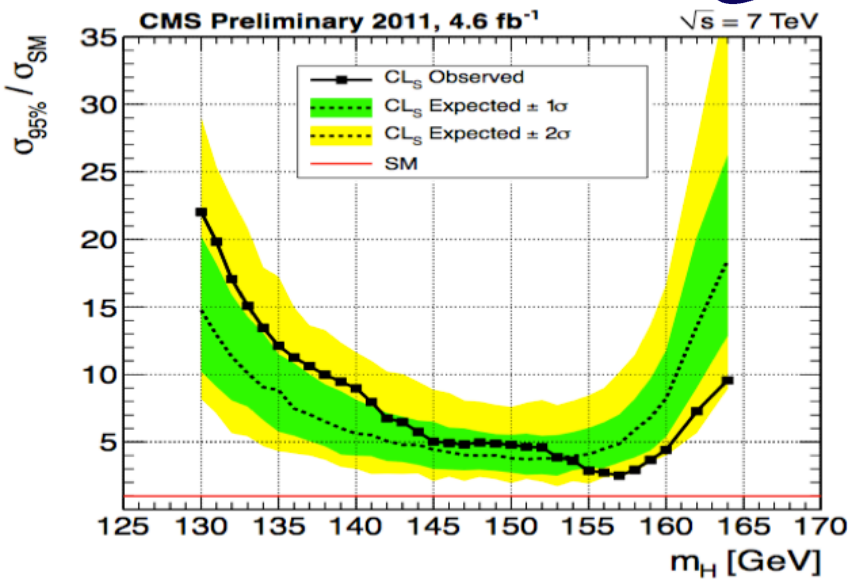


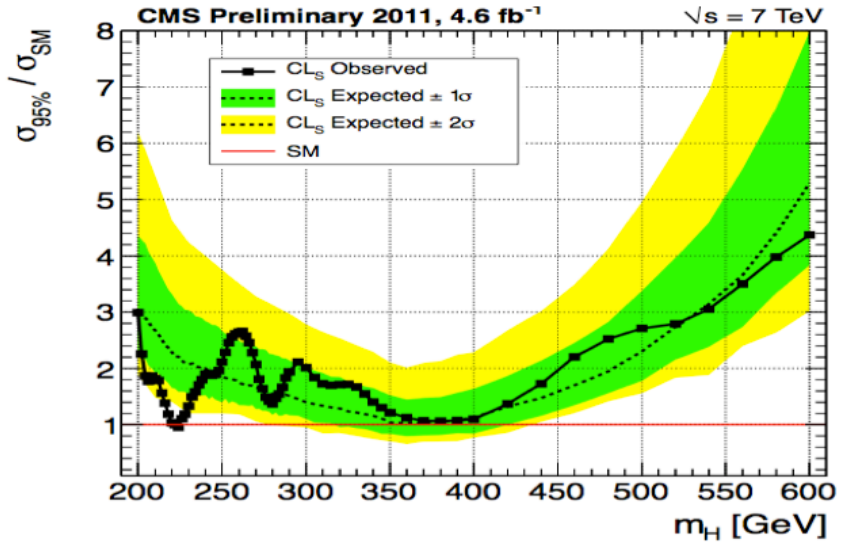




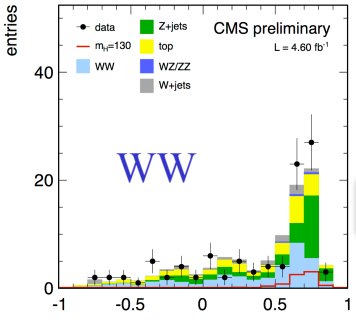
Results and upper limit

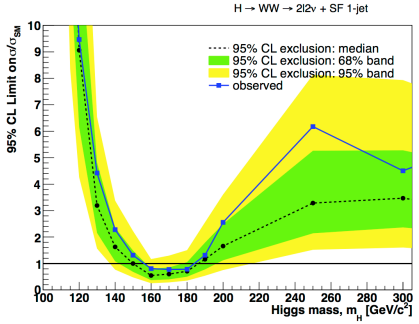


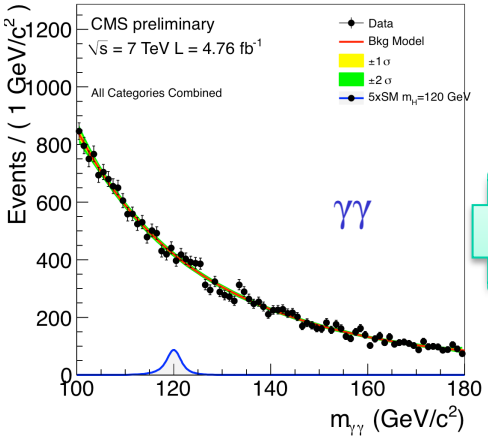


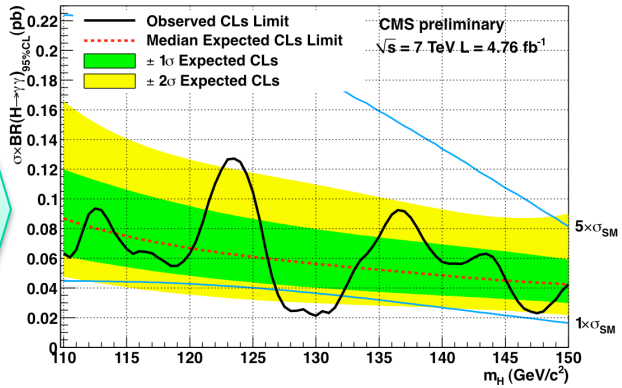


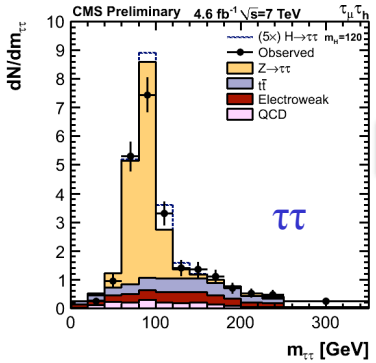
Low mass sensitive channels

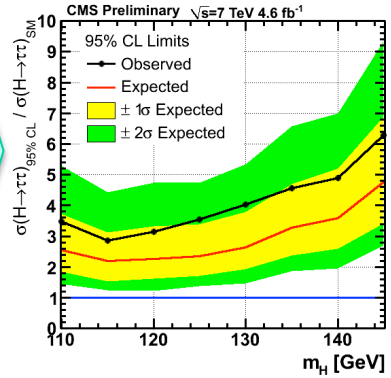


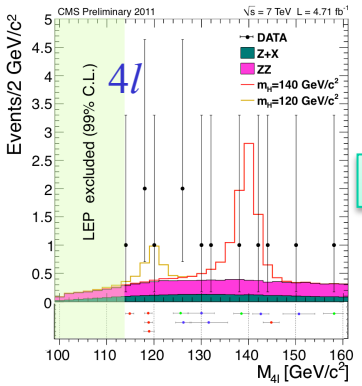


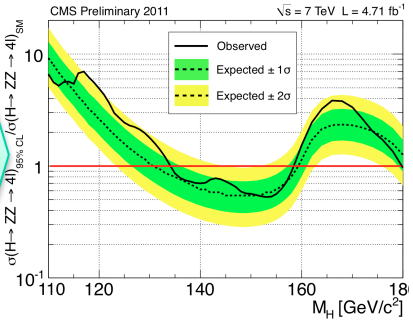


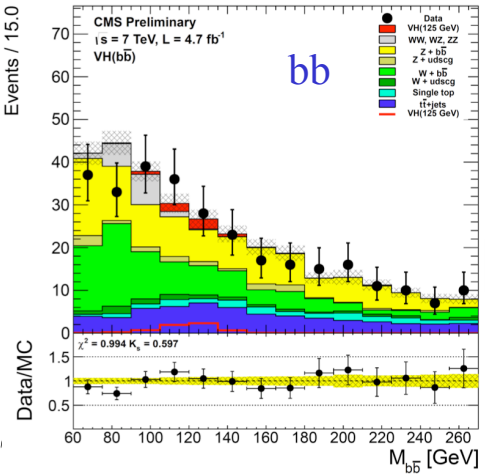


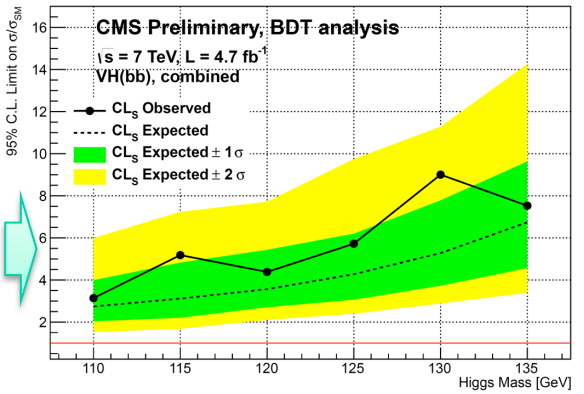




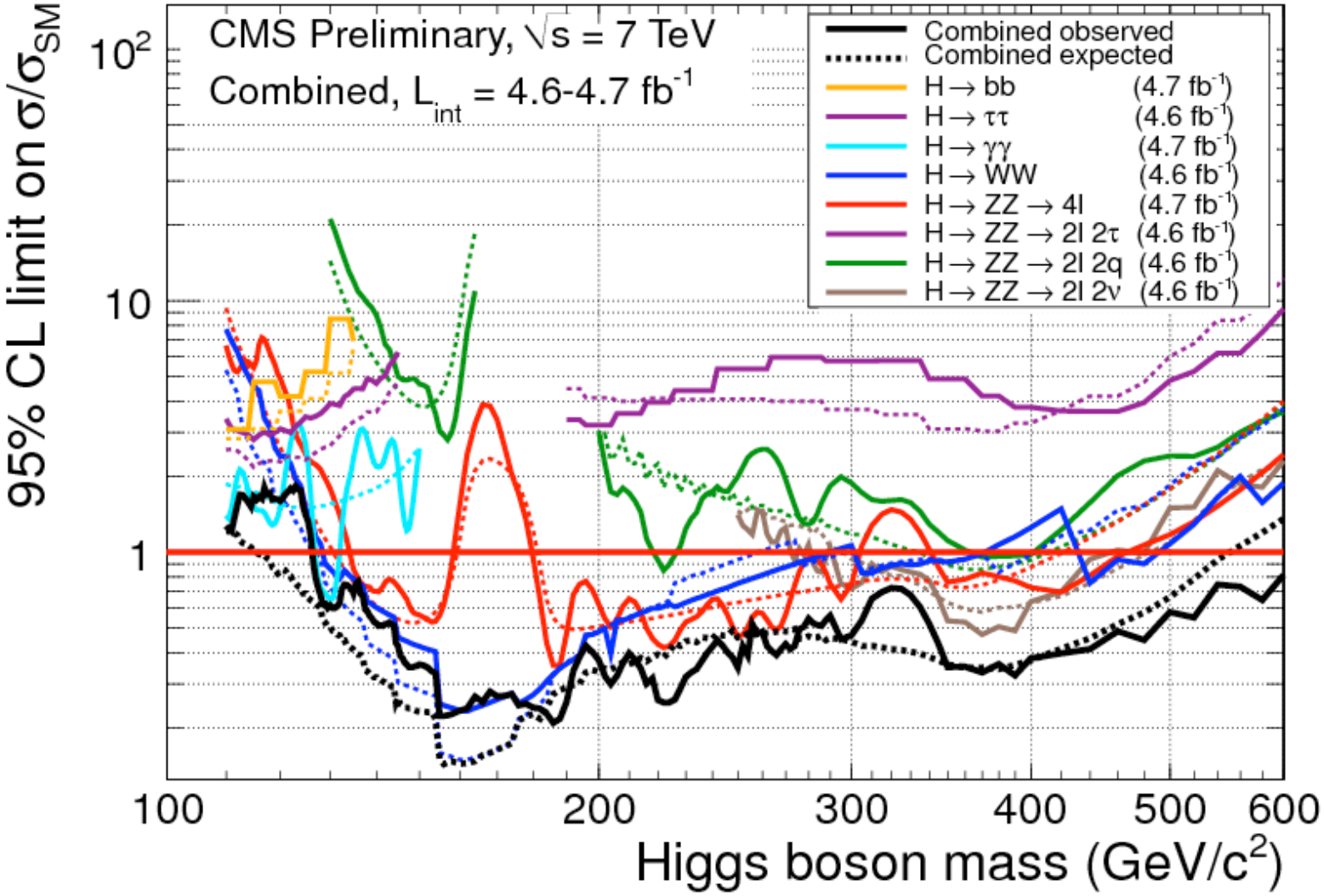




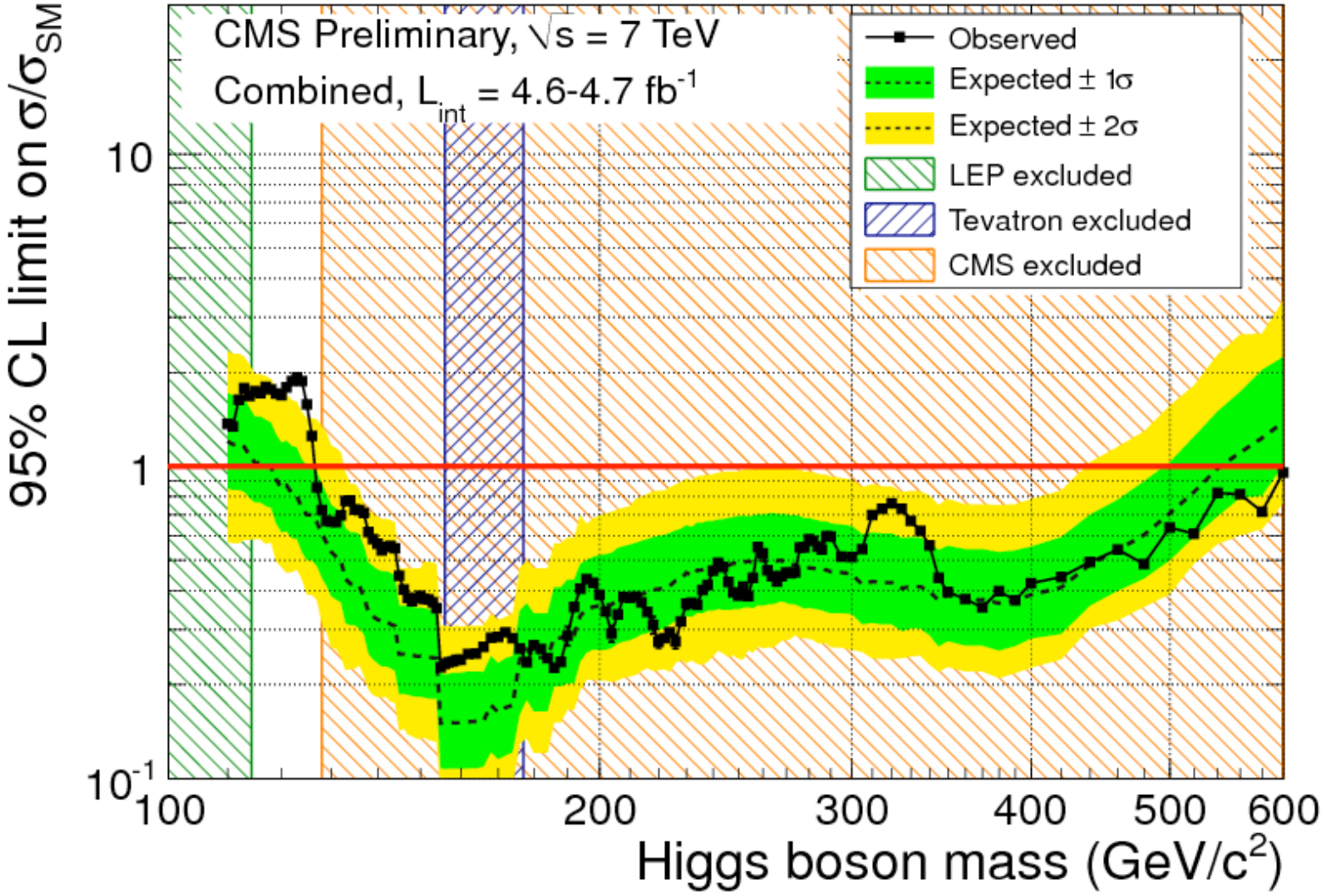




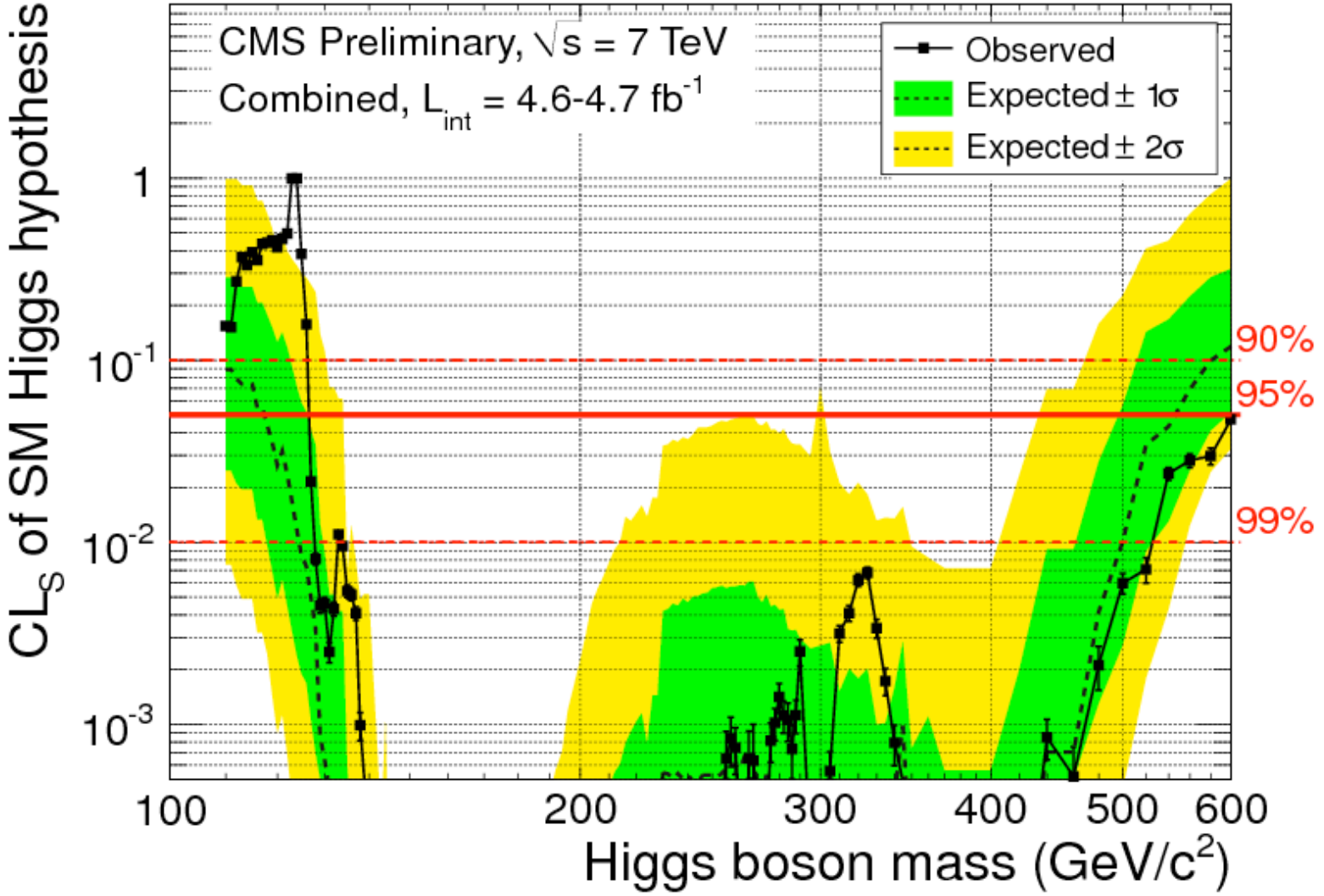
CMS combined limit on σ/σ_{SM}



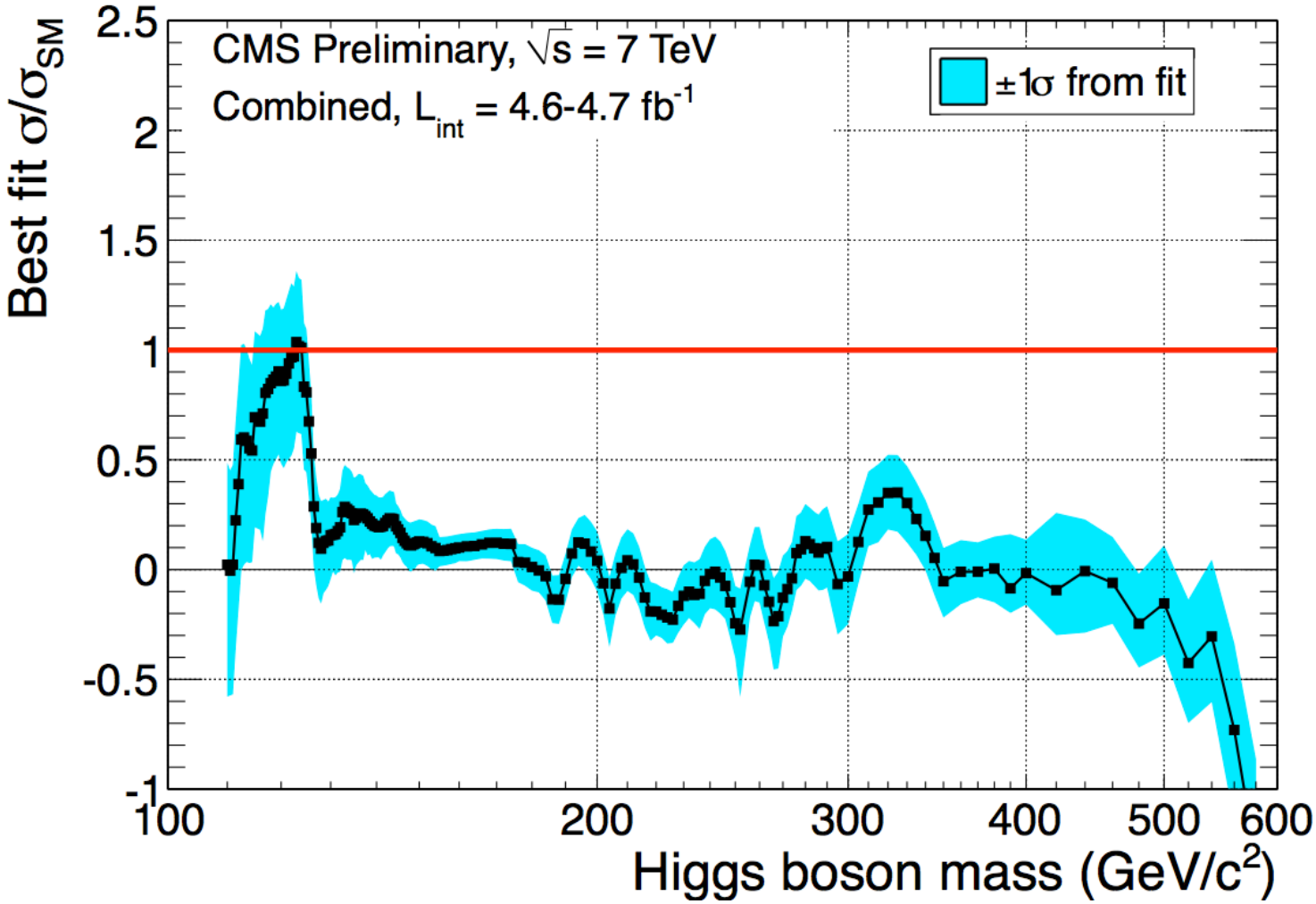
Higgs mass 95% CL exclusion



CLs of Higgs signal hypothesis

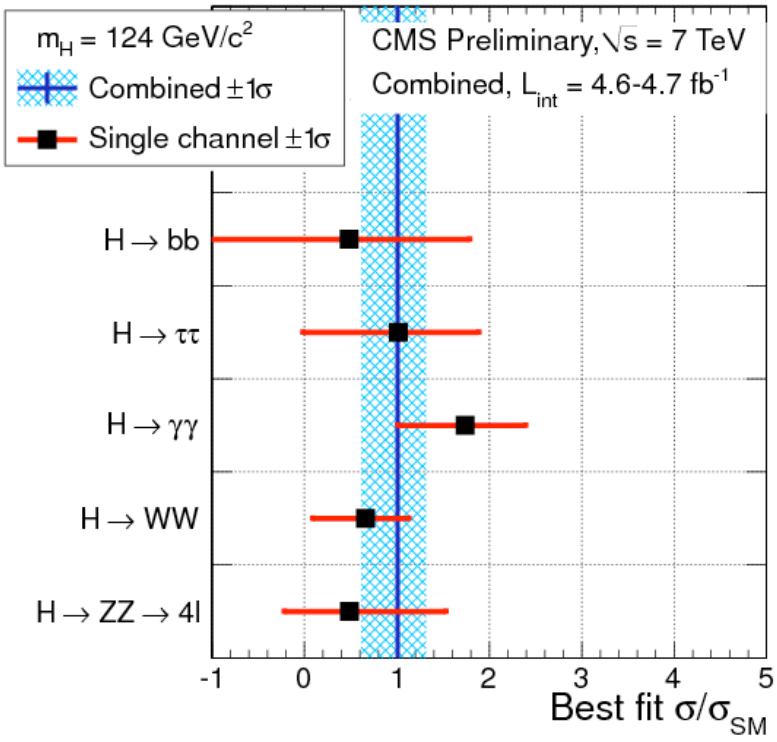


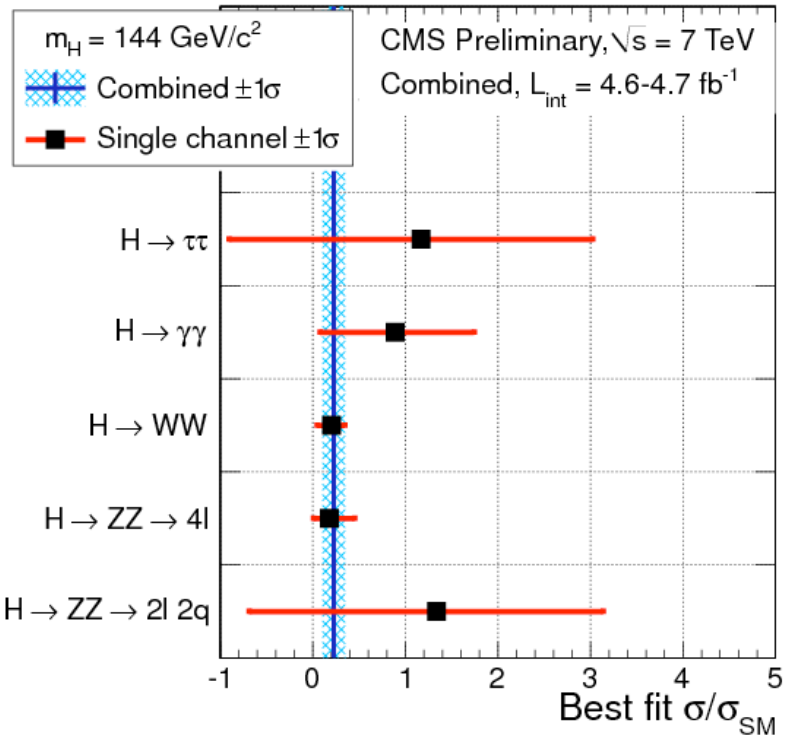
Cross section "measurement"



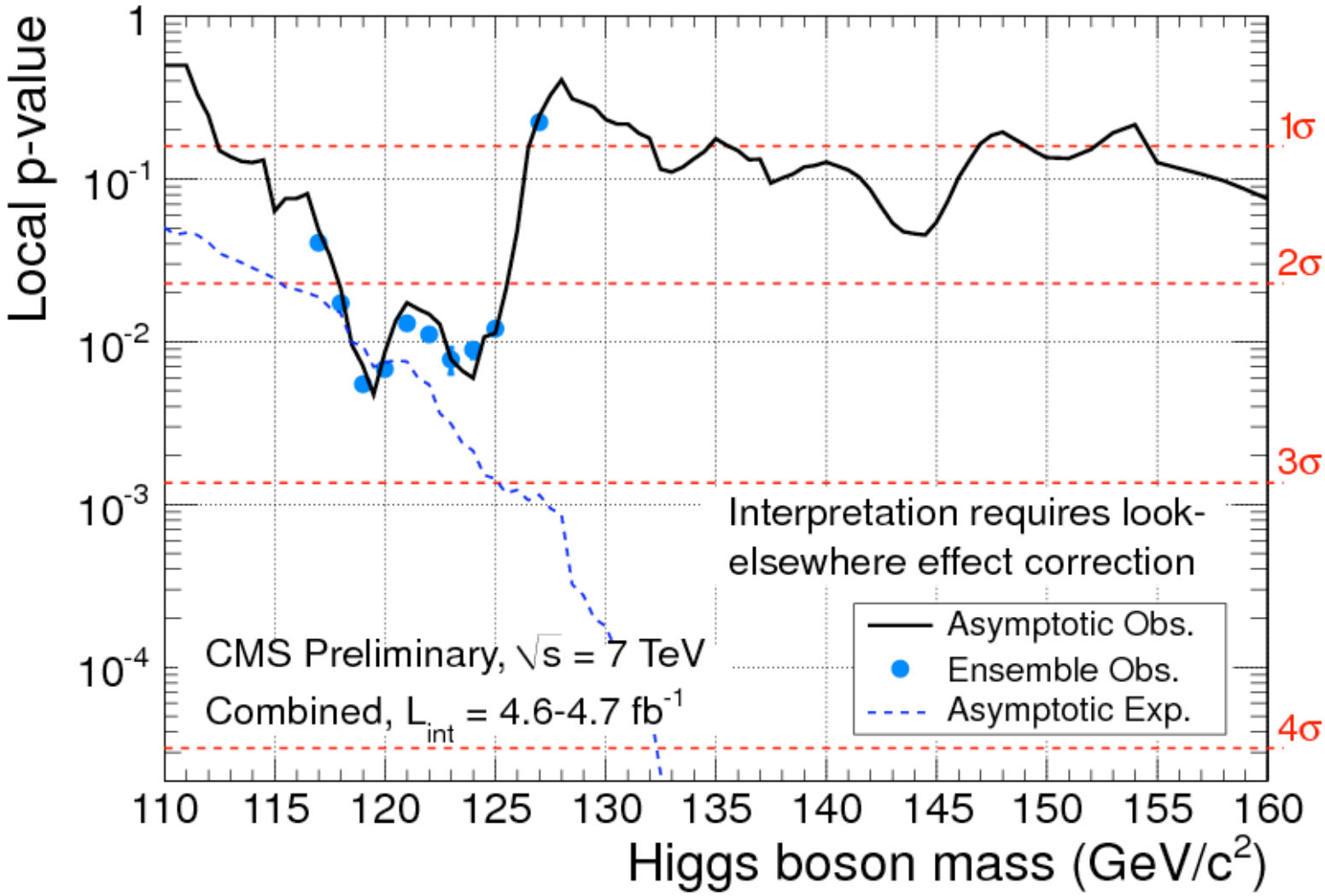
Channel comparison

- Best fit σ/σ_{SM} of the various channels.
- Excess quite consistently seen in all individual channels ±1σ in the low mass region.

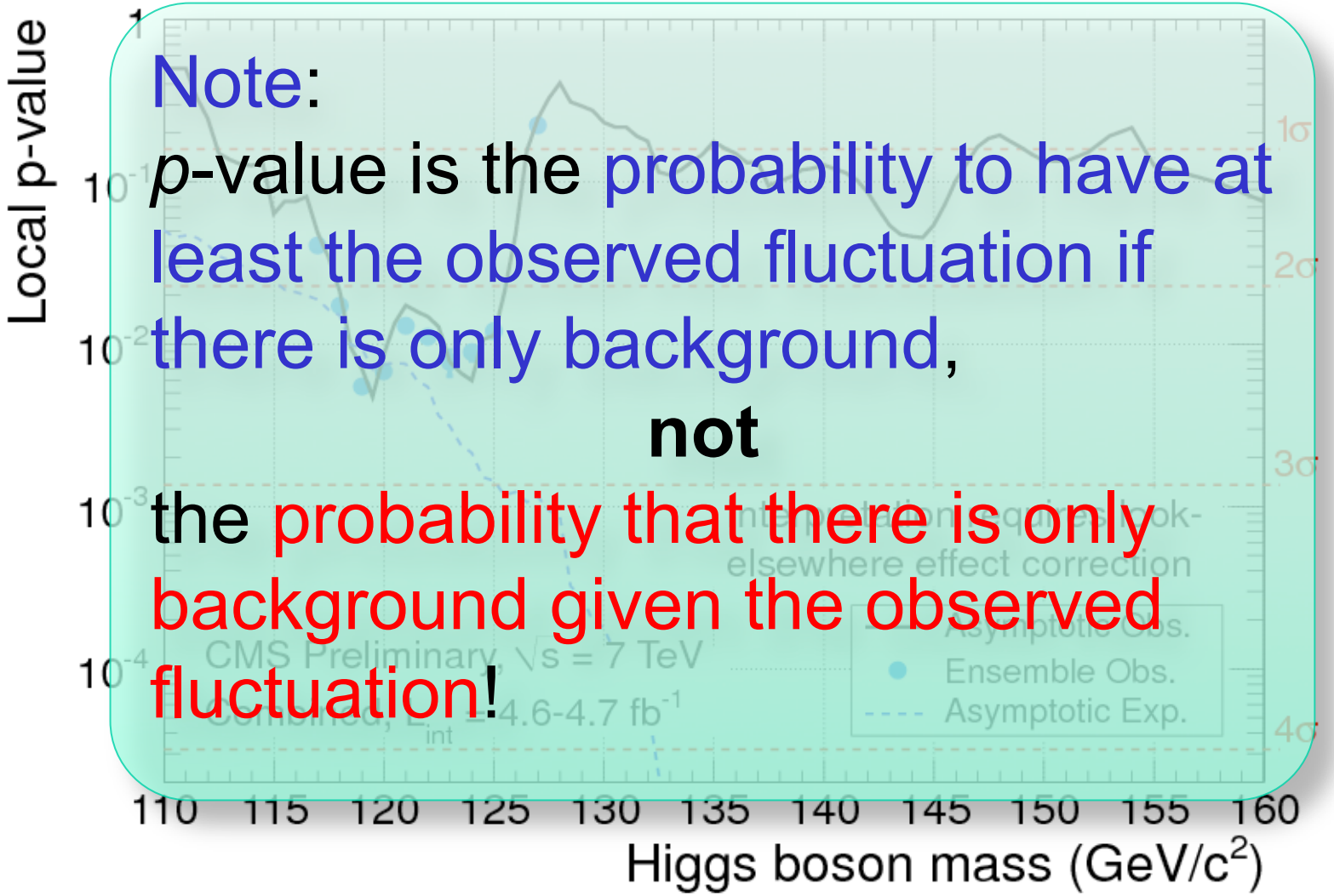




“Hints” or fluctuation?



“Hints” or fluctuation?



Note:

p-value is the probability to have at least the observed fluctuation if there is only background,

not

the probability that there is only background given the observed fluctuation!

Conclusion

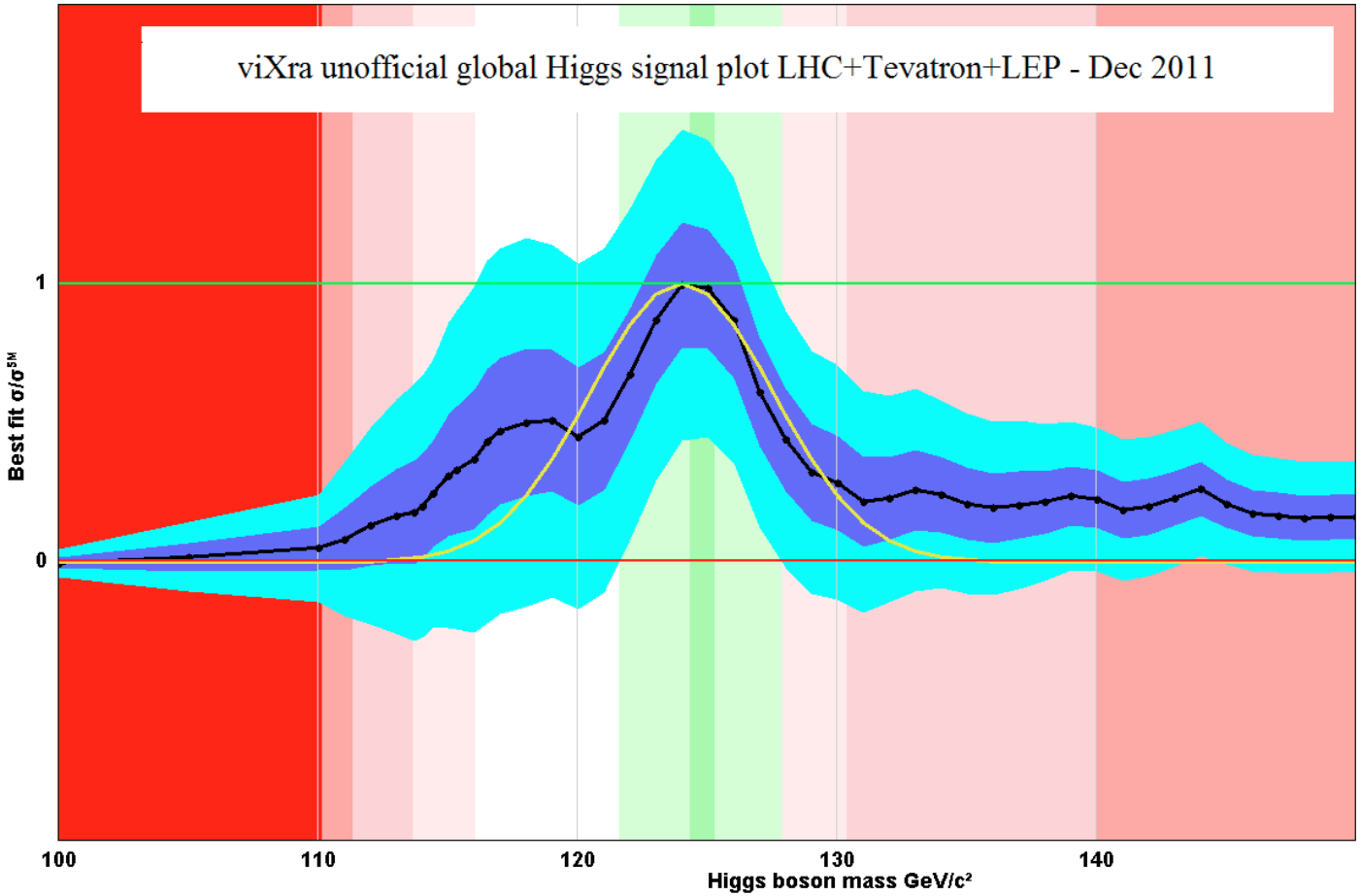
- Fantastic results from CMS thanks to excellent LHC performances
- No signal of new Physics so far
- Not much space left for “minimal” SuSy
- Hints of Higgs boson signal don’t yet allow to establish presence or exclusion

- Stay tuned for next year!

- … and finally a bit of sociology →

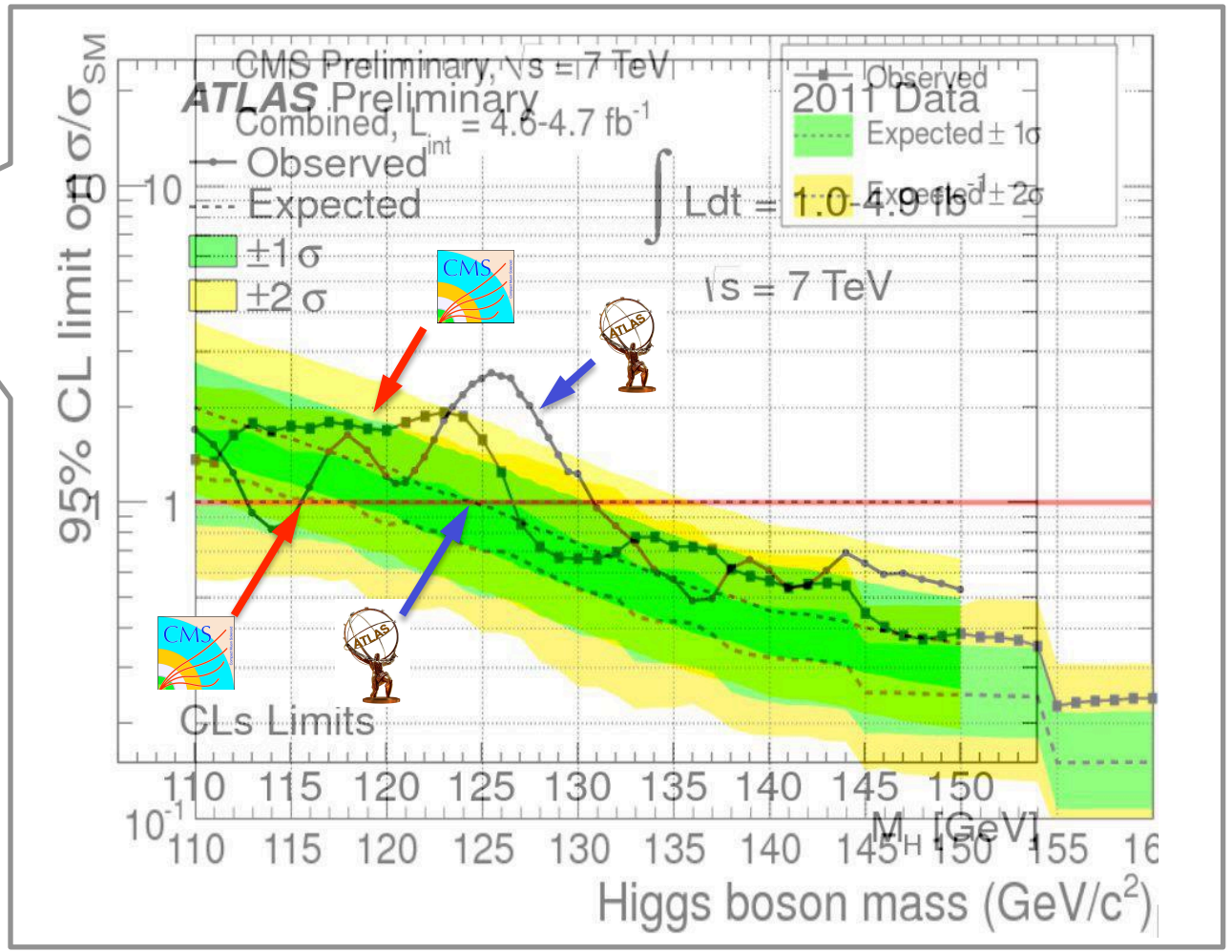
Bloggers' combination

- viXra.org, reported by A Quantum Diaries Survivor



Higgs comparison from FB

- ATLAS vs CMS comparison, circulated on FB




LA MIA E' CLASSE FANTOCCI,
IL SUO E' C…
1:04 / 2:23
360p