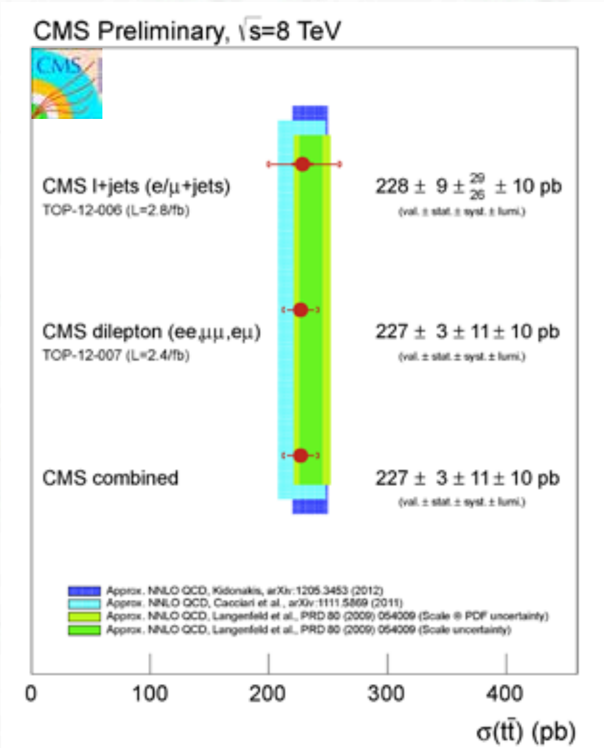
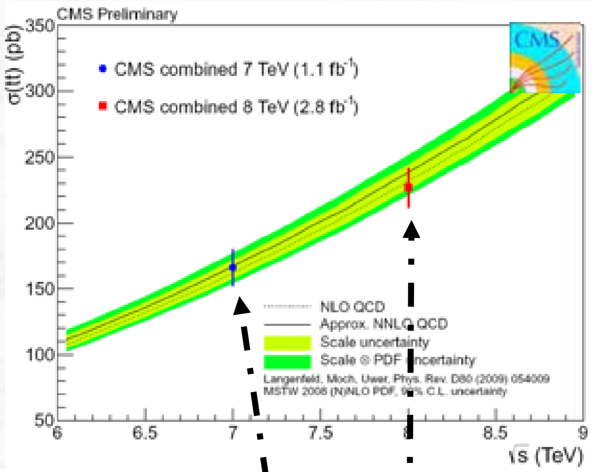
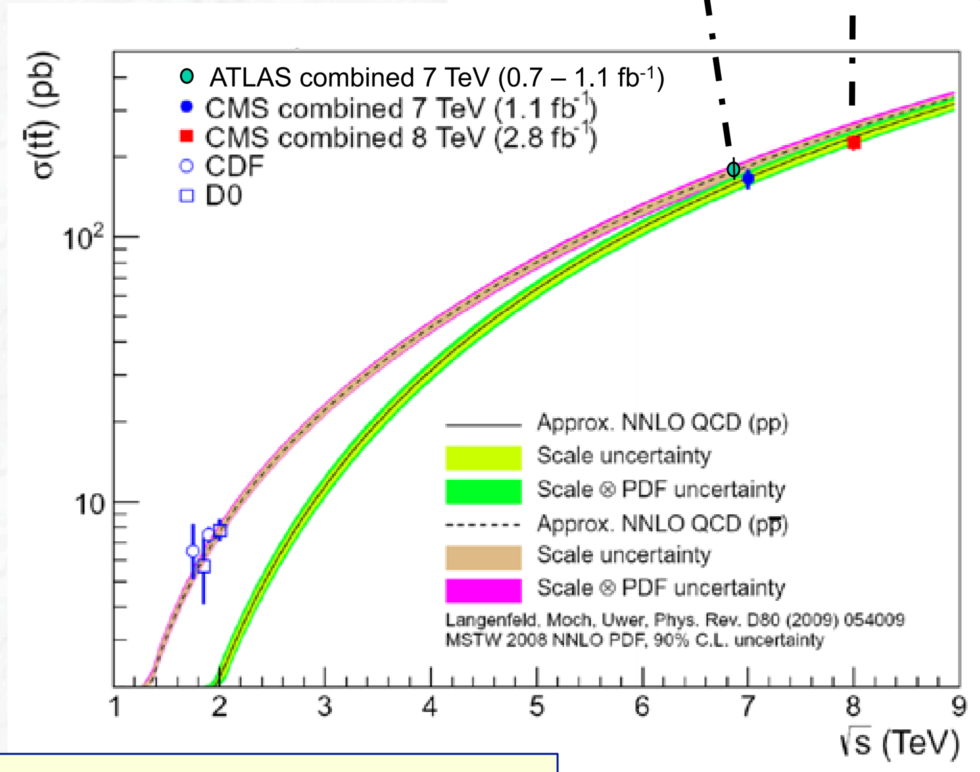
- CMS: new measurement at 8 TeV !

- Lepton + jets and di-lepton channels combined:

σ = 227 ± 3 (stat) ± 11 (syst.) ± 10 (lum.) pb





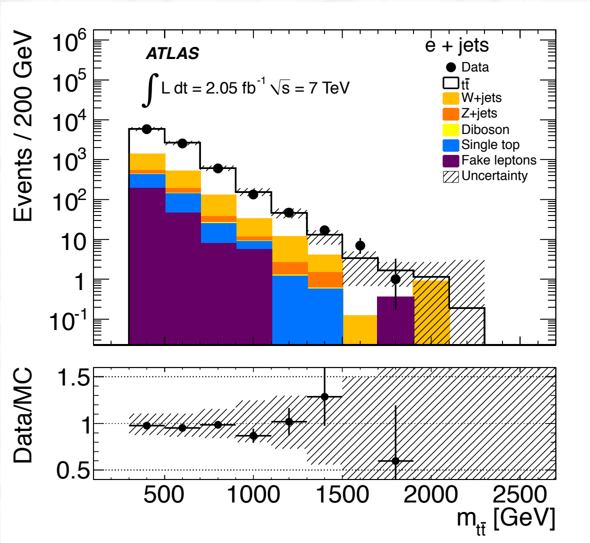


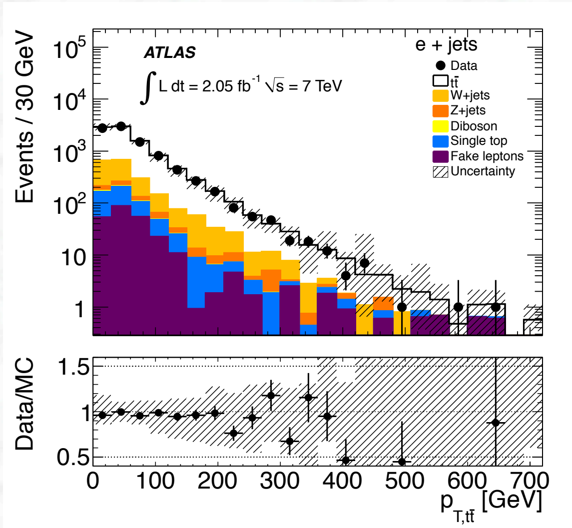
σ(8TeV)/σ(7TeV) = 1.41 ± 0.11; no correlation assumed

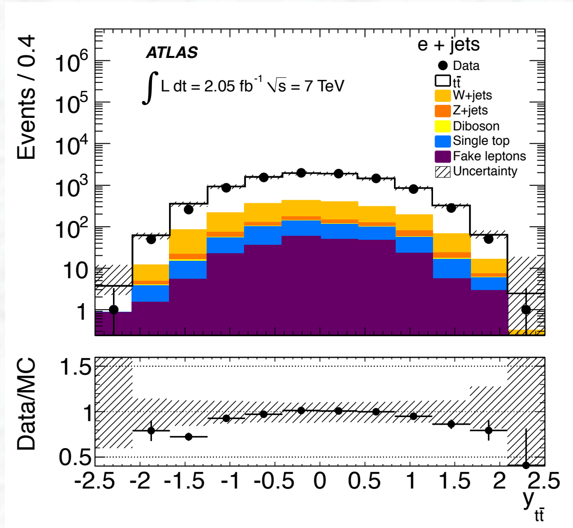
Top-antitop differential cross sections

- Important test of the Standard Model (perturbative QCD), deviations may indicate new physics
  e.g. new particles (resonances) decaying into tt, or other new/unexpected effects (→ Tevatron charge asymmetry)

- Important variables studied: - tt mass distribution
  - Rapidity y and p_T of the tt system







ATLAS comparison on detector level shows good agreement in all variables (background partially extracted from data)

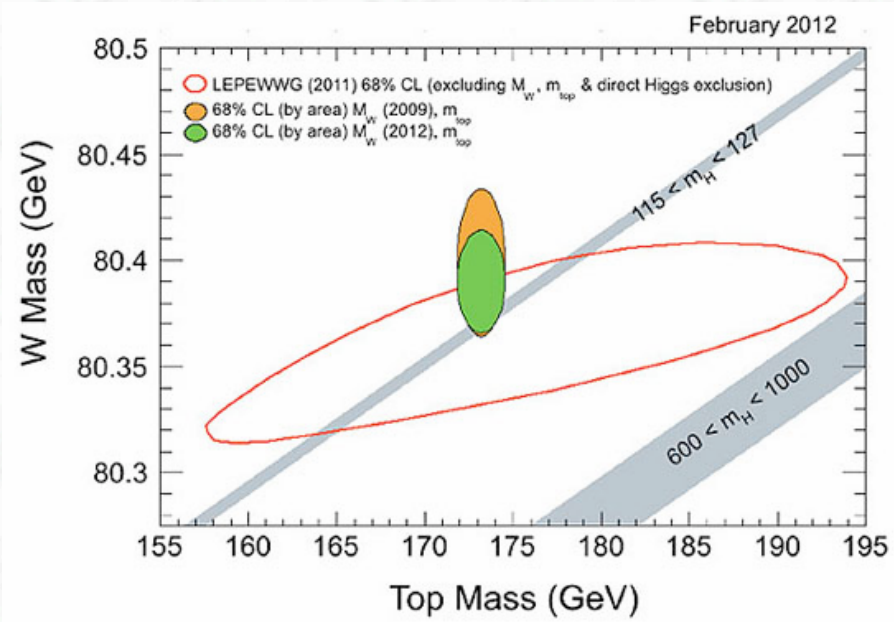
→ not much room left / no signs yet of Physics beyond the Standard Model

Part 3: Electroweak parameters

- W mass

- Top Quark Mass & Properties

- Gauge Boson pair production
  (WW, WZ, ZZ production)



All this is highly related to the Higgs boson search / discovery or to a consistency check / ultimate test of the Standard Model

Precision measurements of m_W and m_t

Motivation:

W mass and top quark mass are fundamental parameters of the Standard Model;
The standard theory provides well defined relations between m_W, m_t and m_H

Electromagnetic constant
measured in atomic transitions,
e^+e^- machines, etc.

$$m_W = \left(\frac{\pi \alpha_{EM}}{\sqrt{2} G_F} \right)^{1/2} \frac{1}{\sin \theta_W \sqrt{1 - \Delta r}}$$

Fermi constant
measured in muon
decay

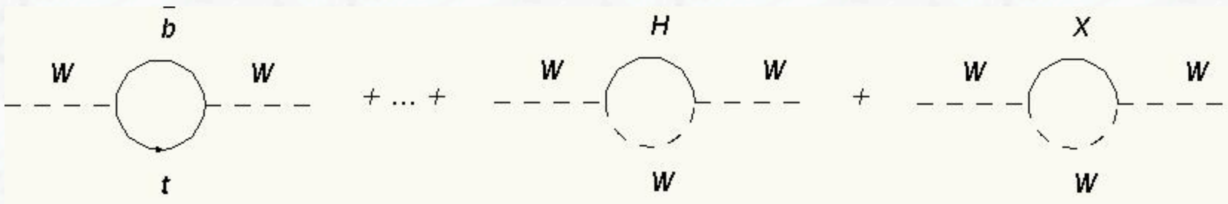
weak mixing angle
measured at
LEP/SLC

radiative corrections
$\Delta r \sim f(m_t^2, \log m_H)$
$\Delta r \approx 3\%$

G_F, α_{EM}, $\sin \theta_W$

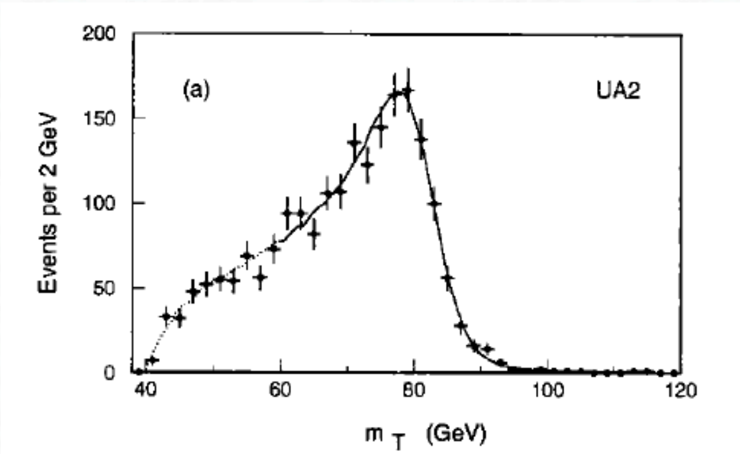
are known with high precision

Precise measurements of the W mass and the top-quark mass constrain the Higgs-boson mass
(and/or the theory,
radiative corrections)



W mass measurements

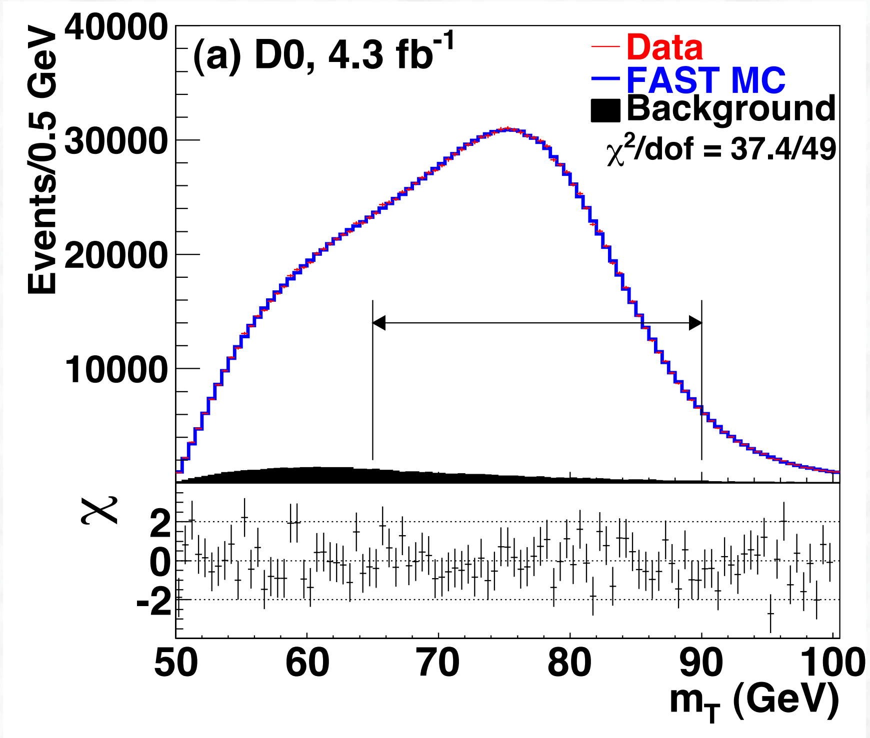
The beginning



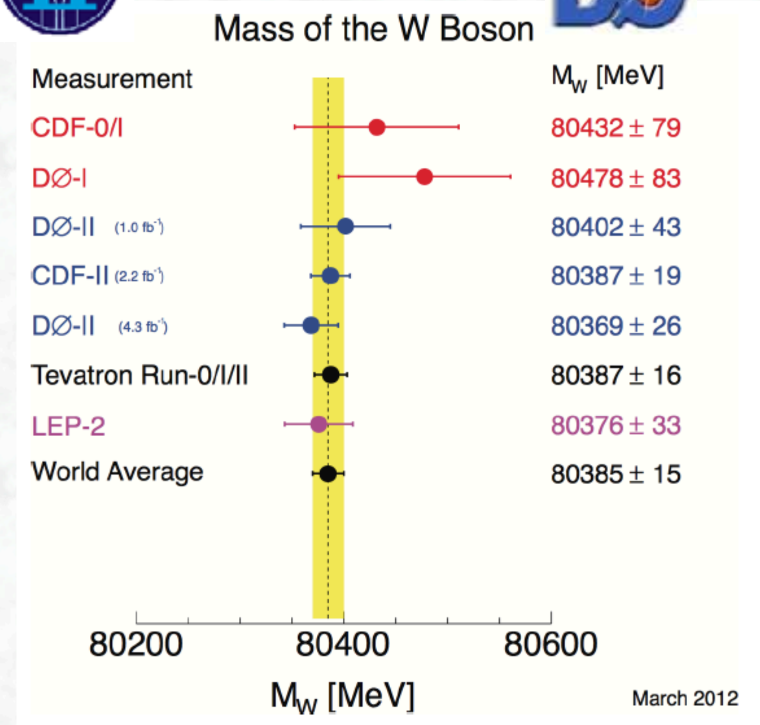
$$m_W = 80.35 \pm 0.33 \pm 0.17 \text{ GeV}$$

State of the art, today

1.68 M events, electrons $|\eta| < 1.05$



m_W = 80.371 ± 0.013 (stat.) GeV

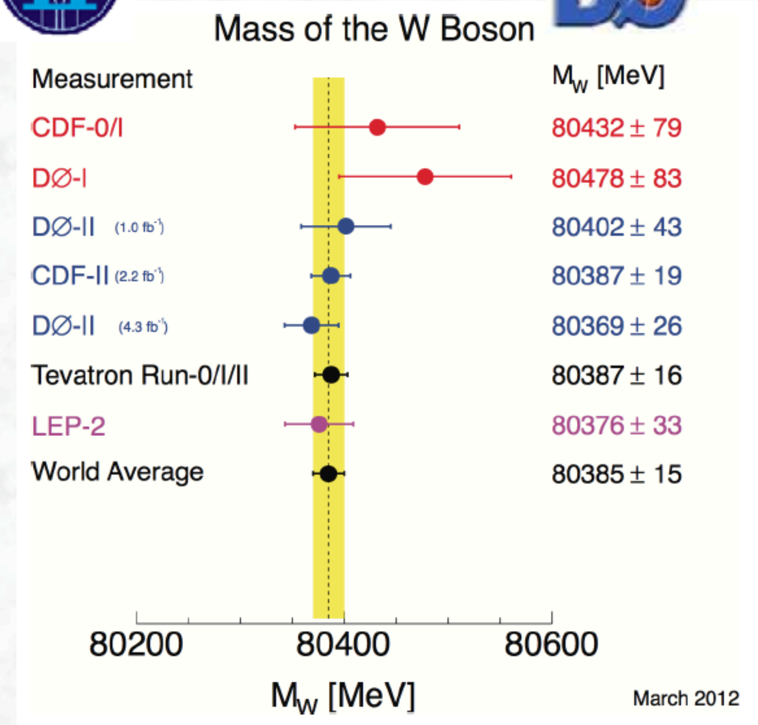


Systematic uncertainties:

New CDF Result (2.2 fb^{-1})
Transverse Mass Fit Uncertainties (MeV)

	electrons	*muons*	*common*
W statistics	19	16	0
Lepton energy scale	10	7	5
Lepton resolution	4	1	0
Recoil energy scale	5	5	5
Recoil energy resolution	7	7	7
Selection bias	0	0	0
Lepton removal	3	2	2
Backgrounds	4	3	0
pT(W) model	3	3	3
Parton dist. Functions	10	10	10
QED rad. Corrections	4	4	4
Total systematic	18	16	15
Total	26	23	

- Precision in a single Tevatron experiment better than the LEP-2 combination
- Still further improvements possible
(inclusion of more data, reduction of statistical and systematic uncertainties)
- Further improvements on parton distribution functions expected (LHC)
- Support from theory side on better calculation / simulation of QED radiation and $p_T(W)$ expected



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Total	26	23	

Can the LHC improve on this?

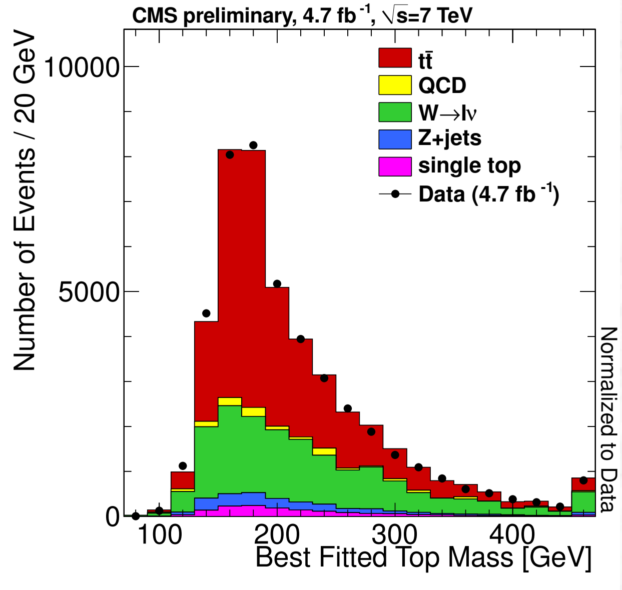
In principle yes, but probably not soon and not with 30 pileup events

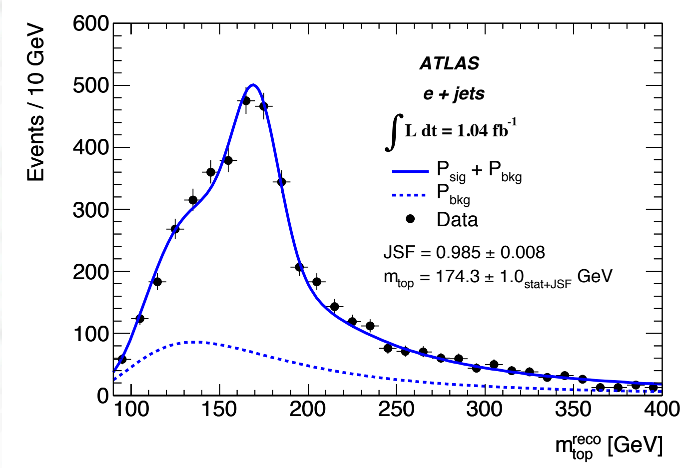
- Very challenging (e-scale, hadronic recoil, p_T (W),..)

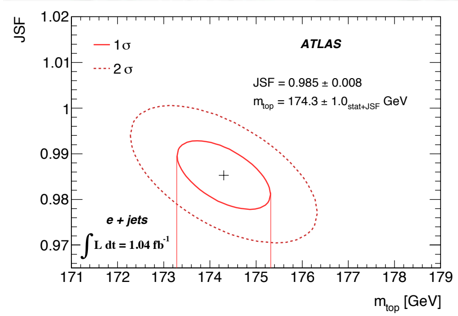
- However, there is potential for reduction of uncertainties
  - statistics
  - statistically limited systematic uncertainties (marked in green above)
  - pdfs, energy scale, …., recoil(?)

First top quark mass measurements at the LHC

- Measurements in all channels available (ll, l+jets, all jets; at least 1 b-tagged jet)
- 2011 data already included
- Combined fit of top mass and jet energy scale (in situ) à la Tevatron







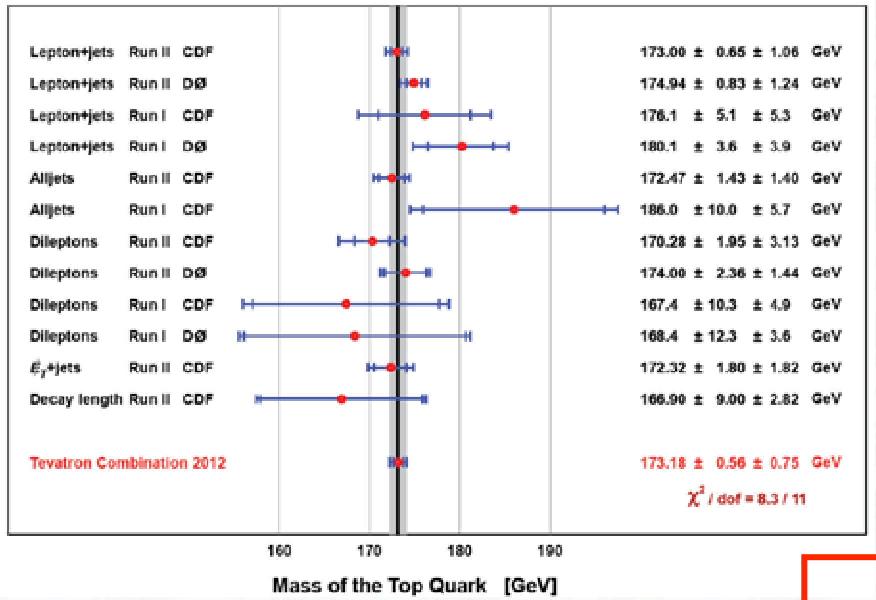
Results of best measurements in the l + jets channels:

CMS:	$m_t = 172.6 \pm 0.5$ (stat) ± 1.5 (syst) GeV
ATLAS:	$m_t = 174.5 \pm 0.6$ (stat) ± 2.3 (syst) GeV

Already impressive precision reached at that early stage of the experiment !

Summary of top quark mass measurements

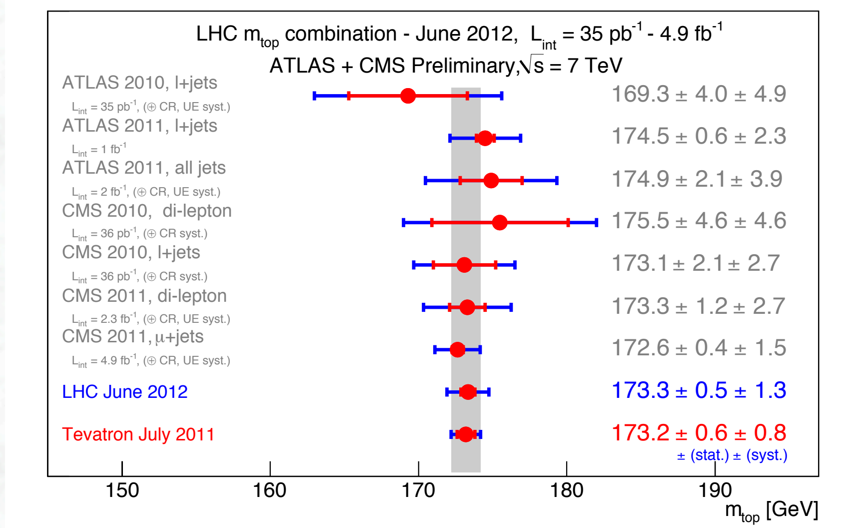
– Tevatron combination



Tevatron:

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

– LHC combination and perspectives

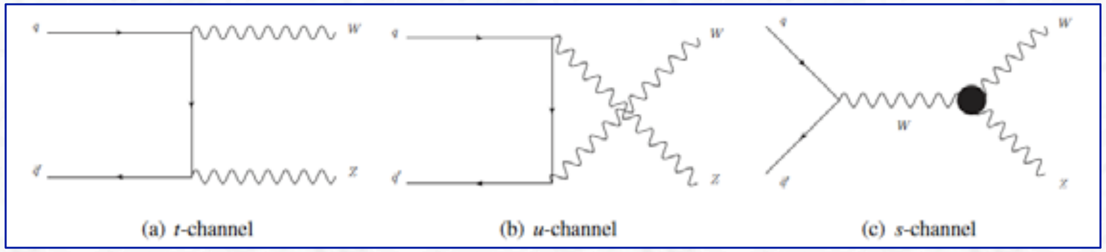


LHC:

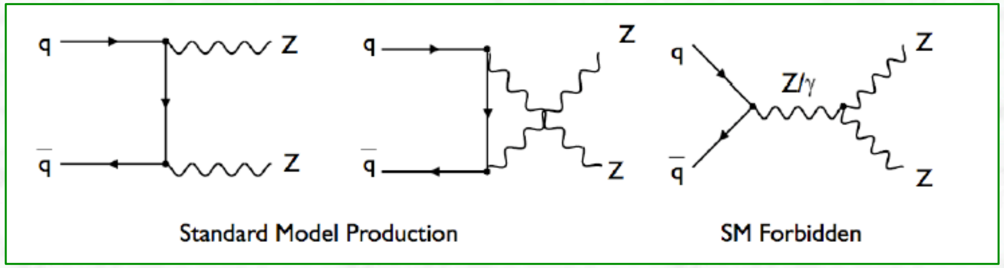
$$m_{top} = 173.3 \pm 0.5\,(\text{stat}) \pm 1.3\,(\text{syst})\ \text{GeV}$$
$$= 173.3 \pm 1.4\ \text{GeV}$$

WZ and ZZ production

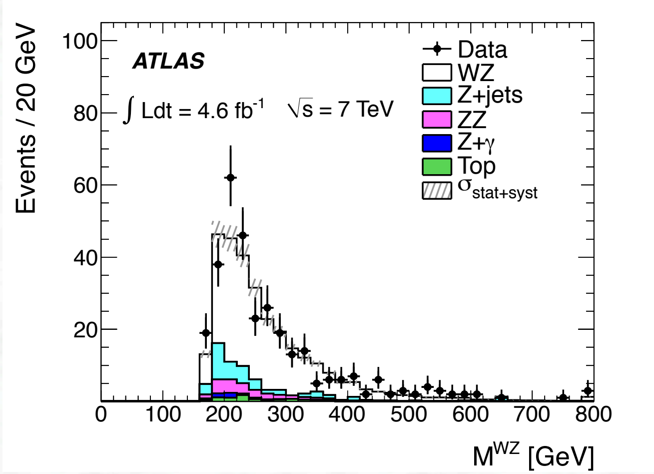
- Expected contributions within the Standard Model (t-, u, s-channel contributions for WZ)

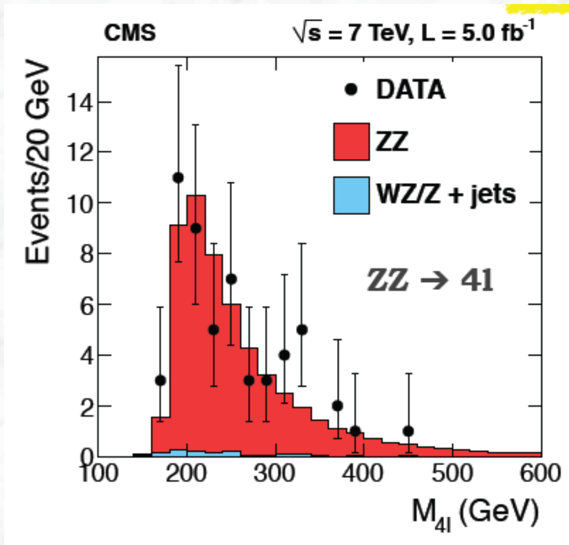


(t- and u- channel contributions for ZZ)

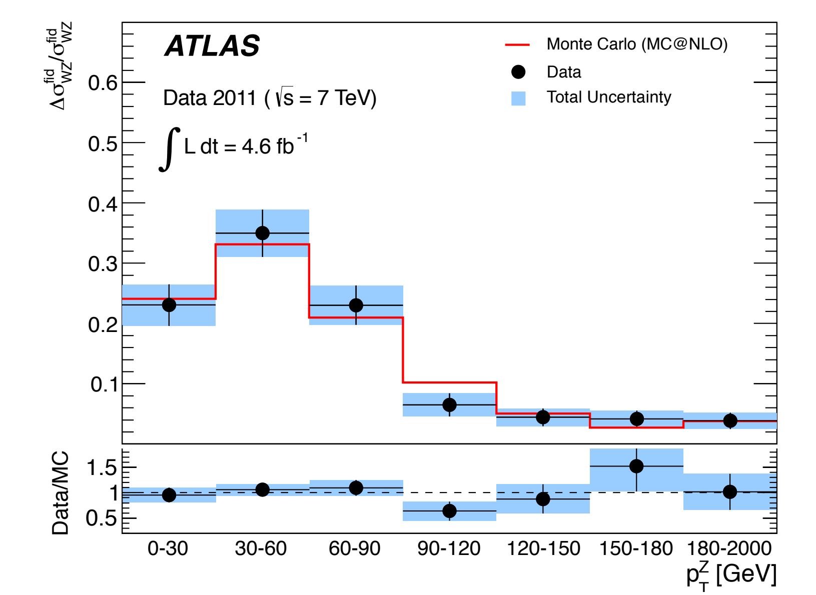


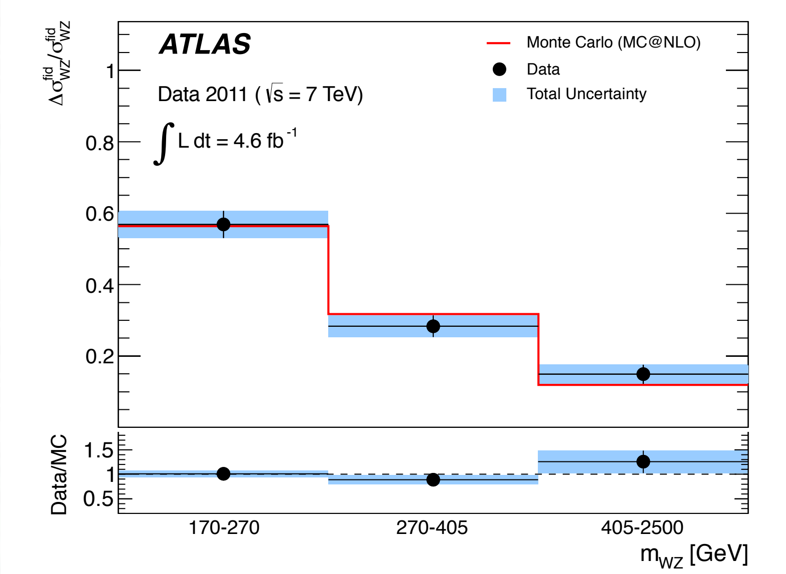
- Search for di-boson production in three (WZ→ lν ll) and four (ZZ→ ll ll) lepton final states
- These are important background processes for Higgs boson searches, e.g. H → 4 l





WZ differential production cross sections

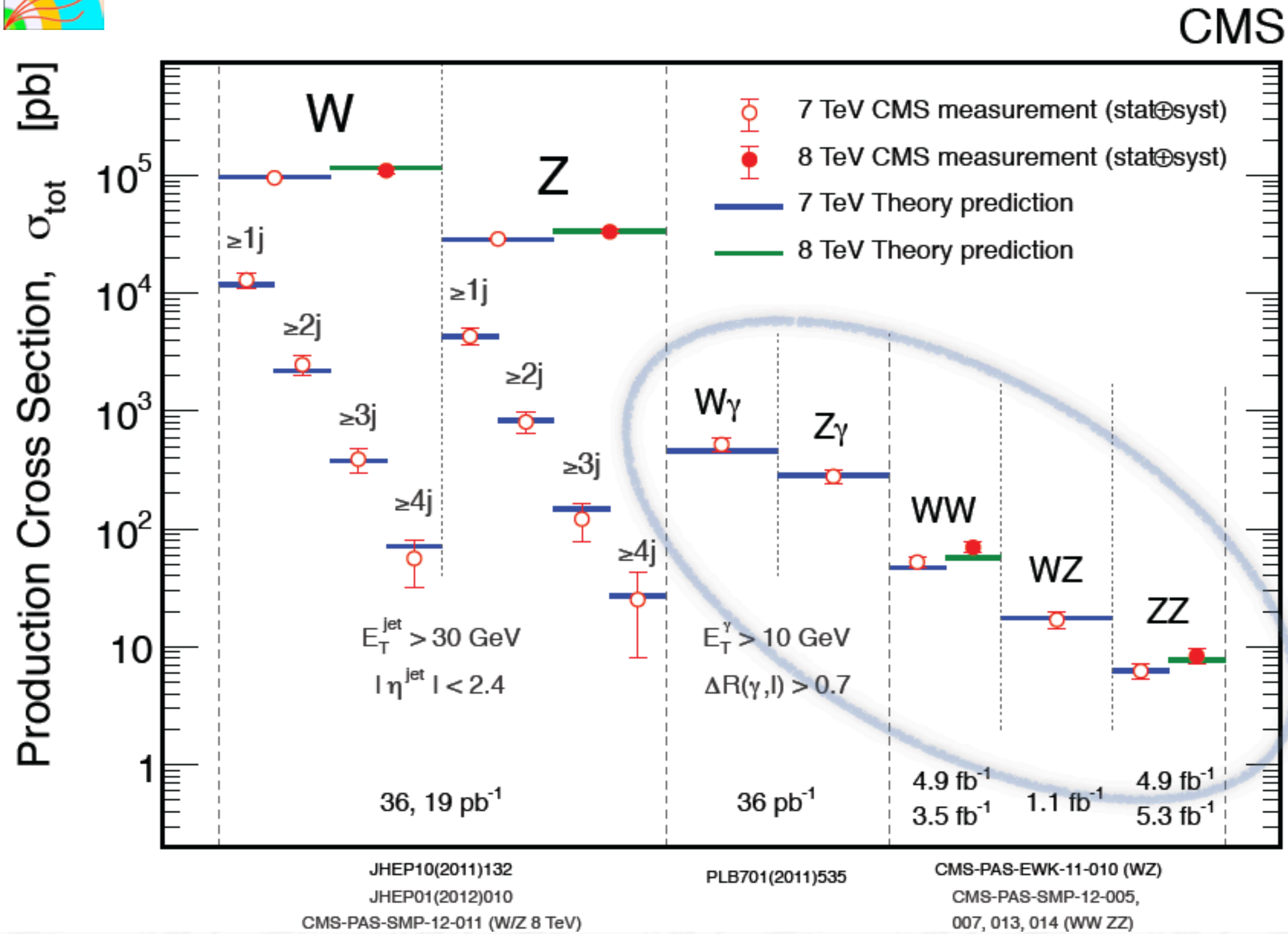




WZ	$N_{observed}$	N_{bkg}	$\sigma_{measured}$ (pb)	σ_{NLO} (pb)
ATLAS	317	68 ± 8	$19.0^{+1.4}_{-1.3} \pm 0.8 \pm 0.4$	$17.6^{+1.1}_{-1.0}$
CMS	75 (1.1 fb^{-1})	~9.1	17.0 ± 2.4 ± 1.1 ± 1.0	17.5 ± 0.6

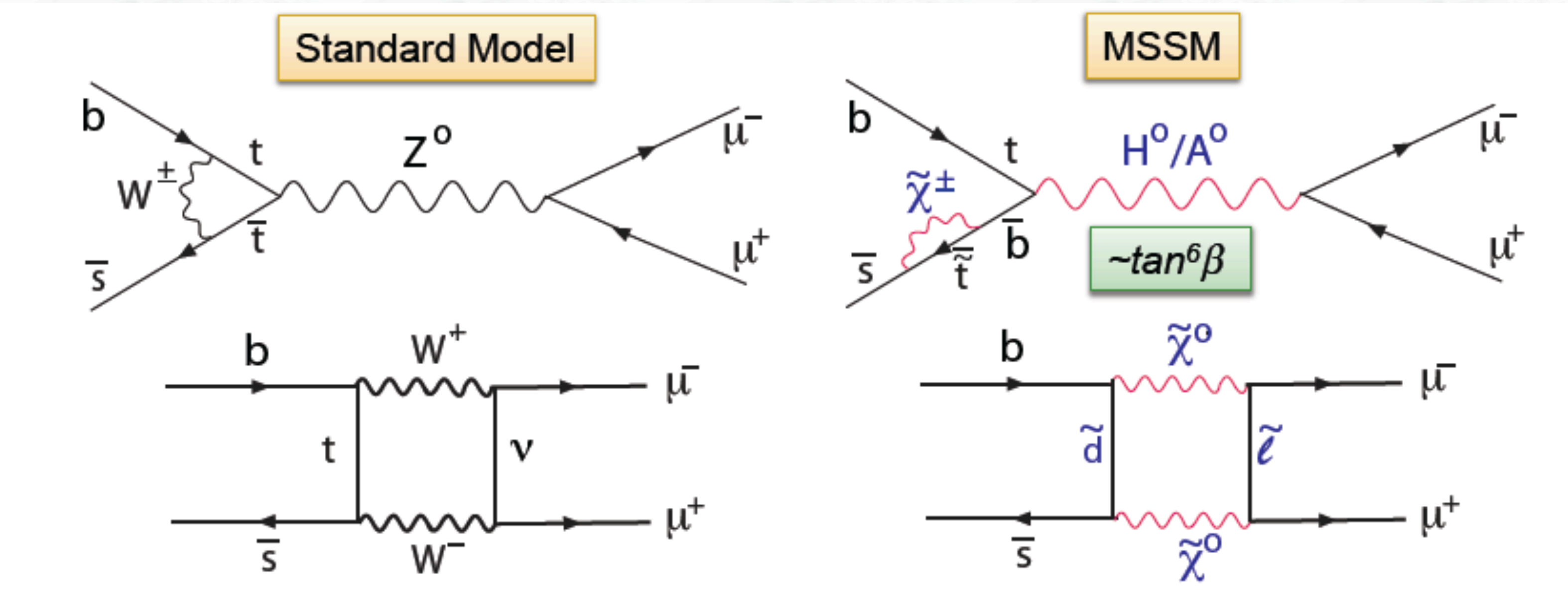
- No indications for anomalous couplings;
- LHC starts to be surpass sensitivity from the Tevatron and LEP; First interesting constraints expected after inclusion of 2012 data

Final cross section summary



Search for the decays $B_0 \rightarrow \mu^+\mu$- and $B_o^s \rightarrow \mu^+\mu^-$

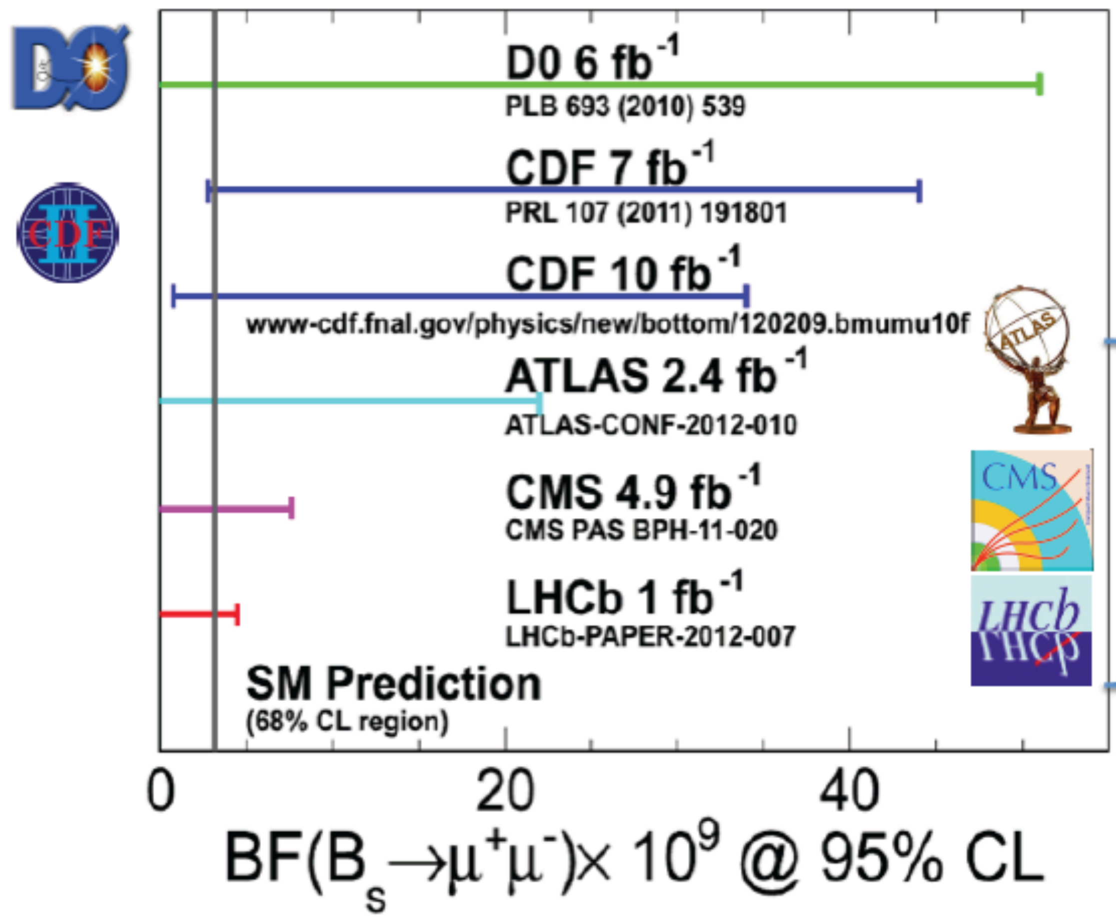
- Rare decay in the Standard Model: Braching ratio for $B_0^s \rightarrow \mu\, \mu$ is $(3.2 \pm 0.2)\ 10^{-9}$
- Contributions from New Physics can be large (also from non-SUSY models)



- Huge b-production rates at the LHC → all LHC experiments are searching for this decay mode

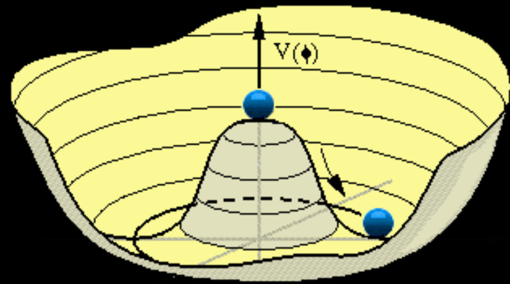
No signal (above backgrounds) found

→ Limits on branching fraction

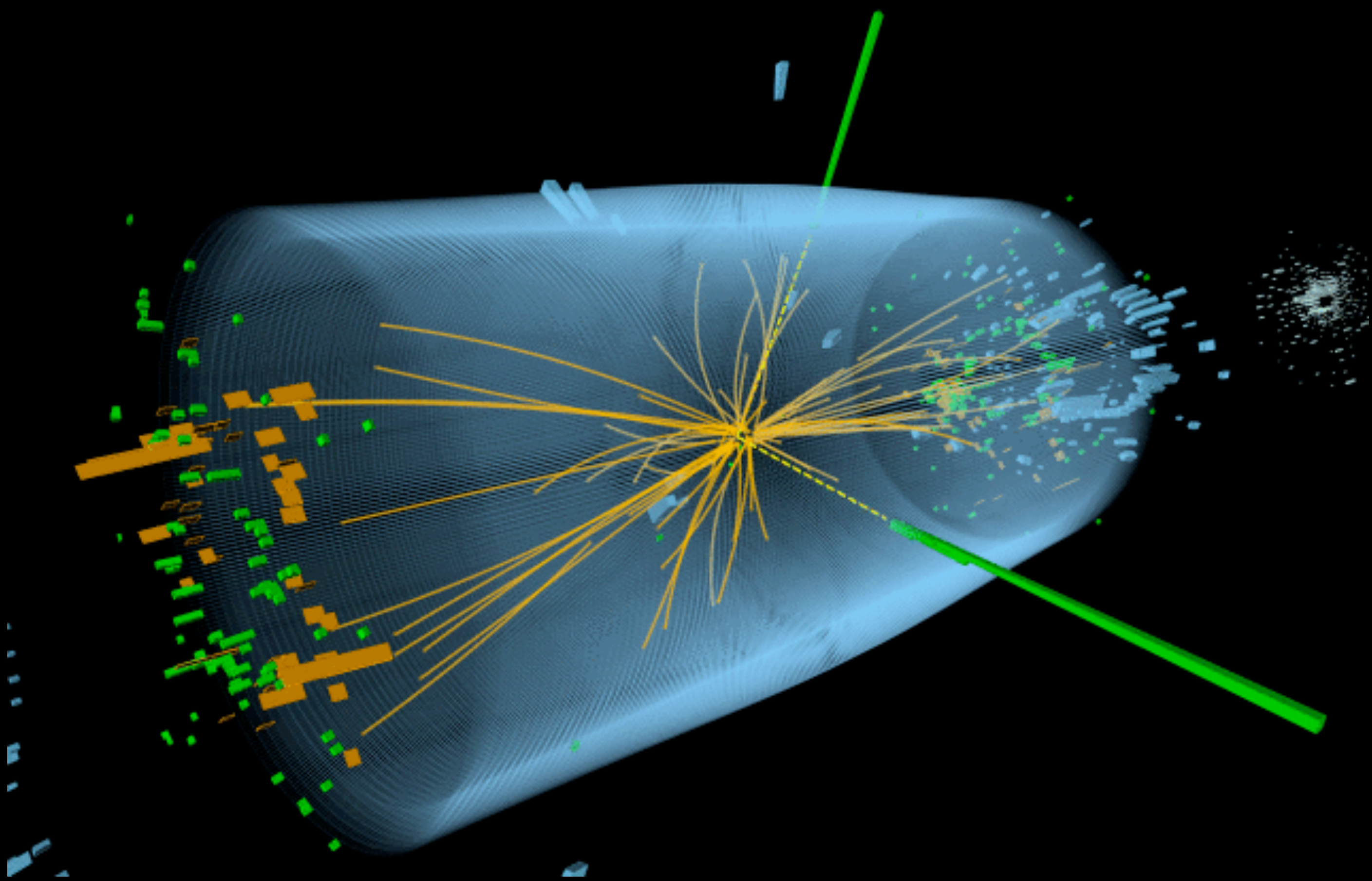


NEW LHC combination…

Part 4: Search for the Higgs Boson



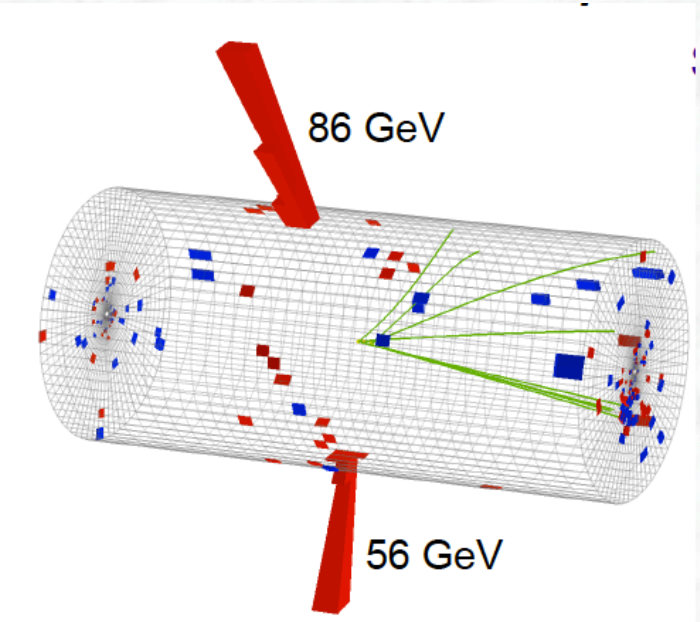
$H \rightarrow \gamma\gamma$ candidate event in the CMS experiment

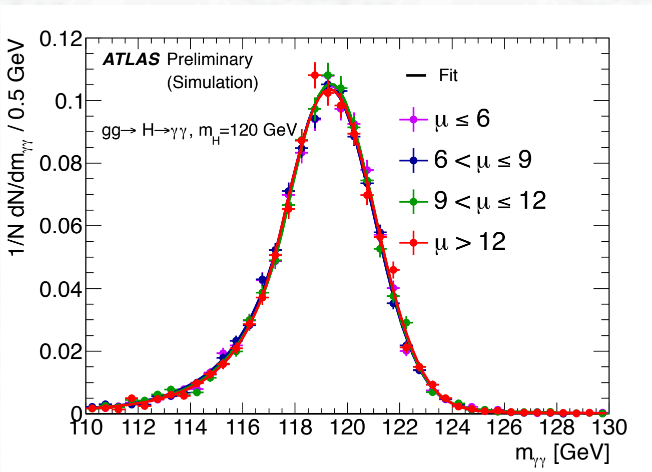


Expected number of decays in data for 12 fb^{-1}:
m_H = 125 GeV

~ 480 $H \rightarrow \gamma\gamma$
~ 30 $H \rightarrow ZZ \rightarrow 4\ l$
~ 4400 $H \rightarrow WW \rightarrow l\nu\ l\nu$

Search for the H → γγ decay





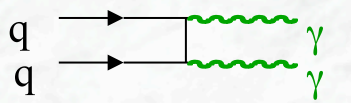
- 2 photons (isolated) with large transverse momenta

- Mass of the Higgs boson can be reconstructed $m_{\gamma\gamma}$

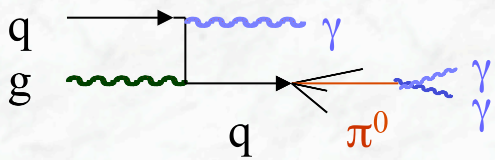
  Both experiments have a good mass resolution
  ATLAS: ~1.7 GeV/c^2 for m_H ~120 GeV/c^2

- Both experiments use different γγ categories according to mass resolution

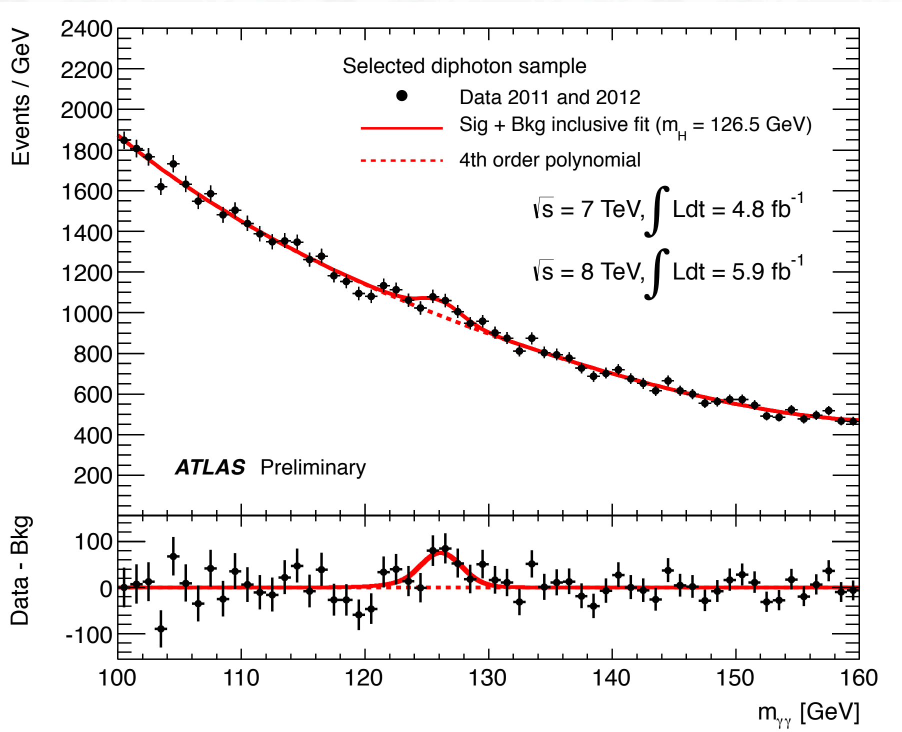
- Challenges:
  - signal-to-background ratio
    (small, but smooth irreducible γγ background)

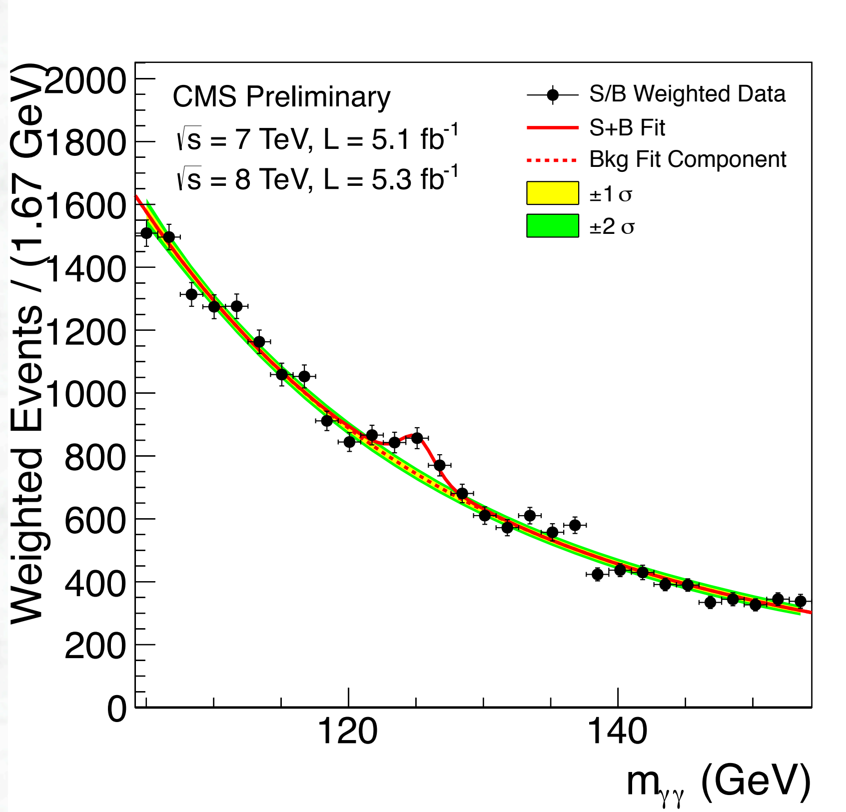


  - reducible backgrounds from γj and jj
    (several orders of magnitude larger than irreducible one)



Measured γγ mass spectra



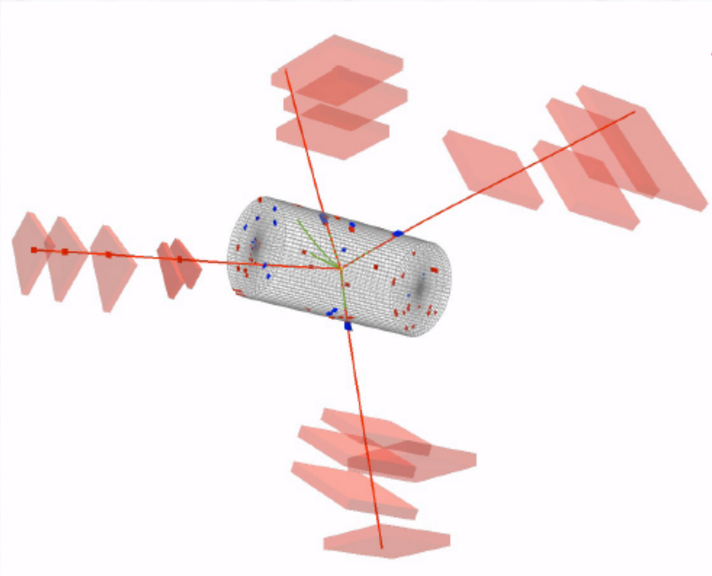


unweighted events, inclusive spectrum

weighted events, according to S/B

- Background model: exponential / polynomial function, determined directly from data (different models have been used → systematics)
- Experiments see excess of events around $m_{\gamma\gamma}$ ~125-126 GeV/c^2
- Use statistical analysis to quantify excess incl. systematic uncertainties on background and signal modelling

Search for the $H \rightarrow ZZ^{(*)} \rightarrow \ell^+\ell^- \ell^+\ell^-$ decay

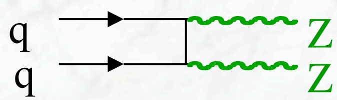


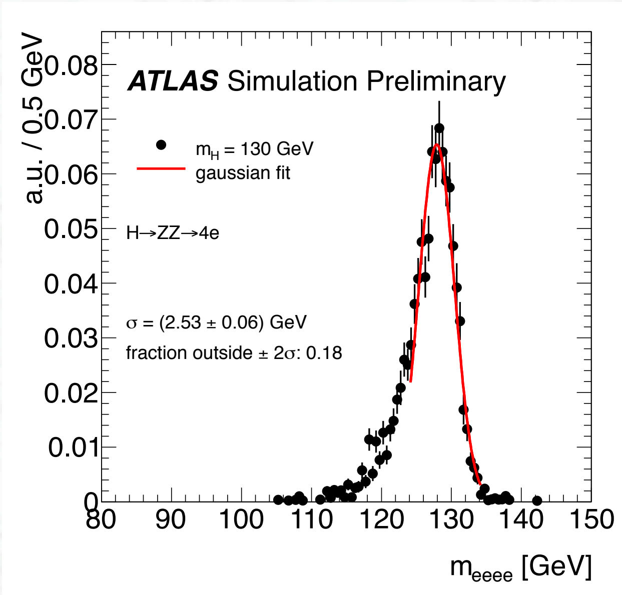
- The “golden mode”
  4 leptons (isolated) with large transverse momenta

- Mass of the Higgs boson can be reconstructed $m_{4\ell}$

  Both experiments have a good mass resolution
  ATLAS: ~2.5 GeV (4e) for m_H ~130 GeV
  ~2.0 GeV (4μ) for m_H ~130 GeV

- Low signal rate, but also low background:
  - Mainly from ZZ continuum

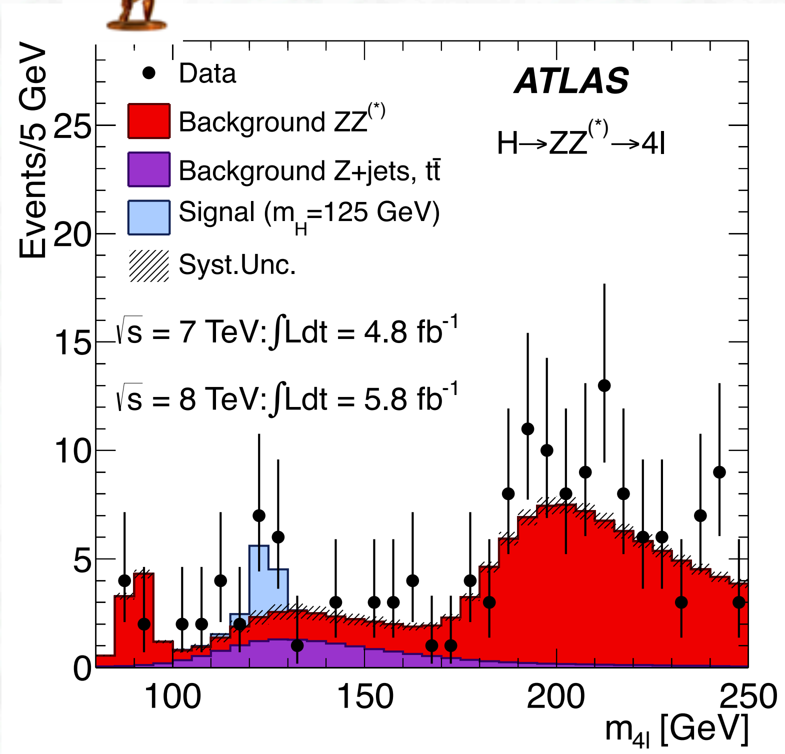


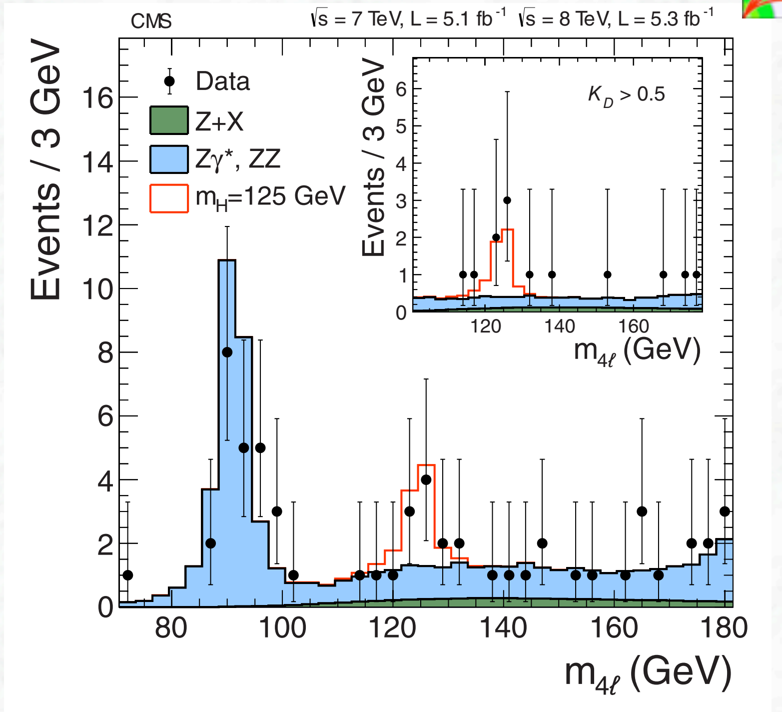


- In addition from tt and Zbb events:
  tt → Wb Wb → $\ell\nu$ c$\ell\nu$ $\ell\nu$ c$\ell\nu$
  Z bb → $\ell\ell$ c$\ell\nu$ c$\ell\nu$
  however: leptons are non-isolated and do not originate from the primary vertex

  rejection possible in excellent LHC tracking detectors

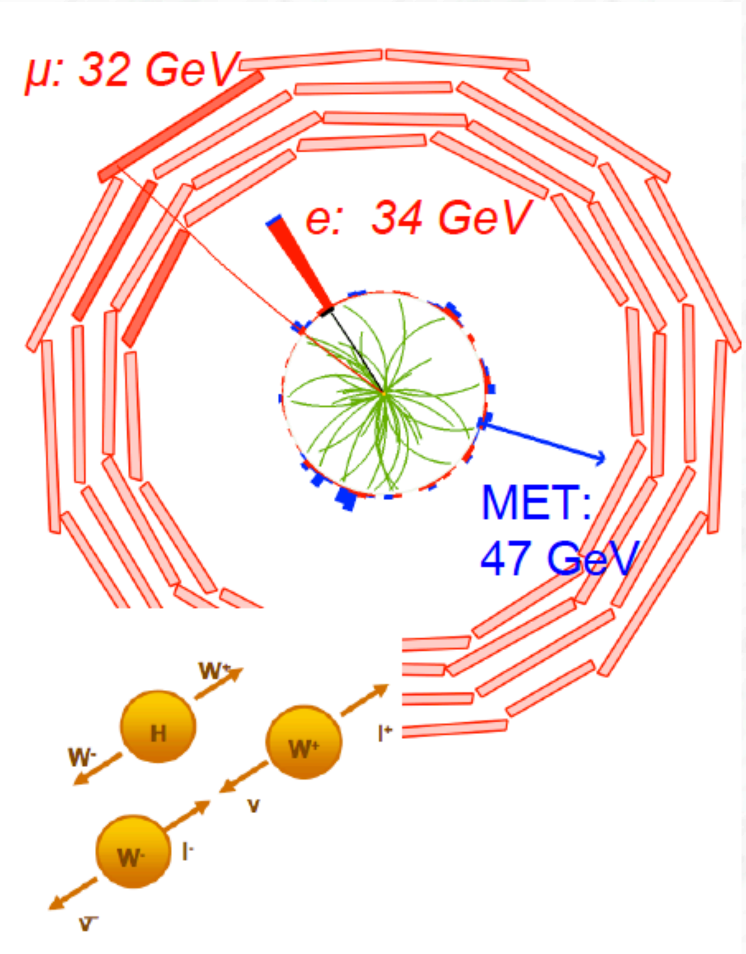
4l invariant mass spectra





- Reducible backgrounds from Z+jets, Zbb, tt giving 2 genuine + 2 fake leptons measured using background-enriched, signal-depleted control regions in data
- Irreducible background from non-resonant continuum ZZ production seem slightly underestimated in NLO Monte Carlo simulation; normalized in high-mass region;

Search for H → WW → ℓν ℓν decay



- 2 leptons (e or μ) with large transverse momenta

  Leptons from Higgs decay (spin-0 particle) are expected to have a small angular separation

- 2 neutrinos

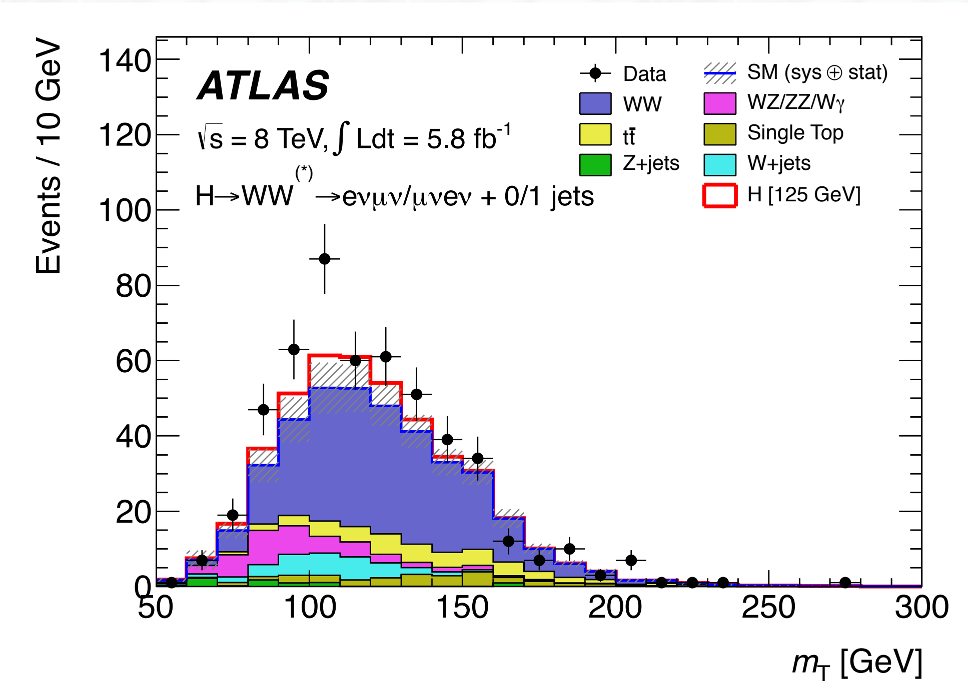
  → large missing transverse energy

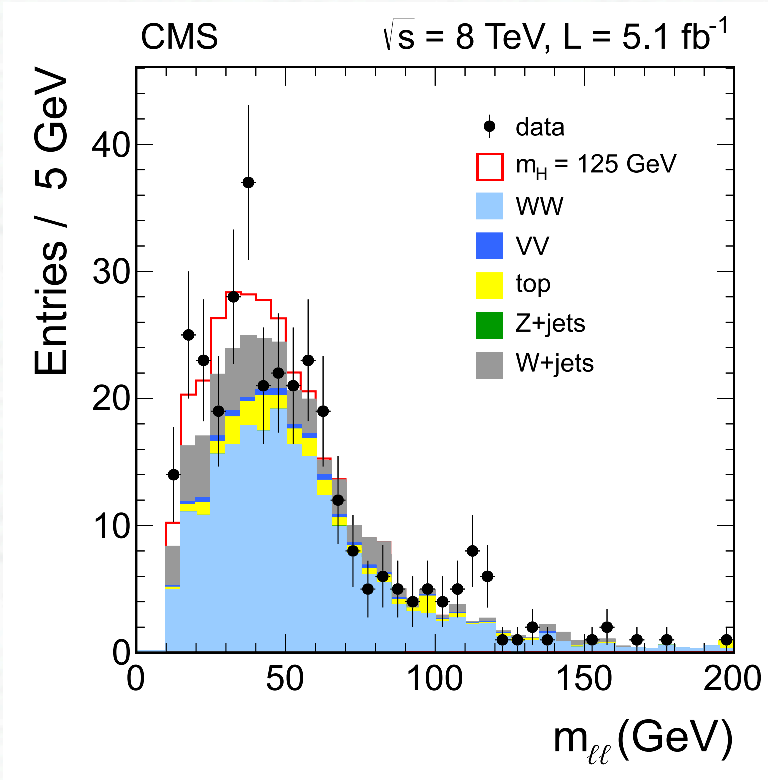
  → Higgs boson mass cannot be reconstructed, use transverse mass m_T

- Highest sensitivity around 160 GeV

  (nearly 100% H → WW branching ratio)

$H \rightarrow WW \rightarrow \ell\nu\ \ell\nu$



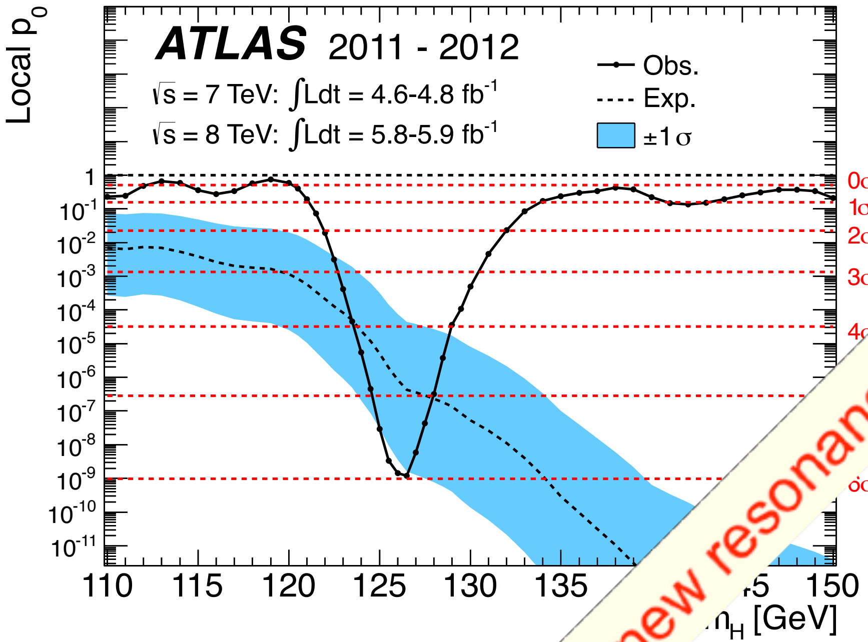


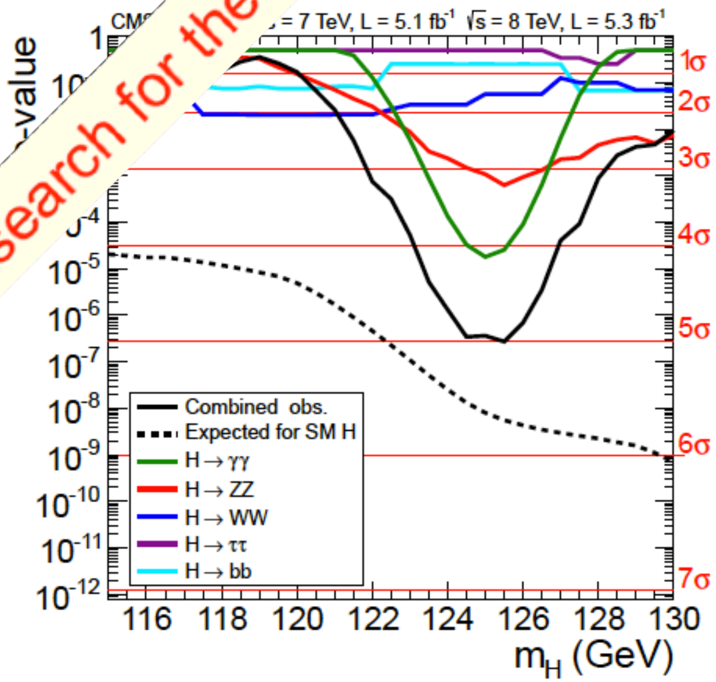
Updated ATLAS analysis (since 4th July) including the 2012 data

new

Test of background-only hypothesis for the combin... of the γγ, ZZ, WW, ττ and bb channels -ATLAS and CMS-

Observation of a new resonance in the search for the Higgs boson

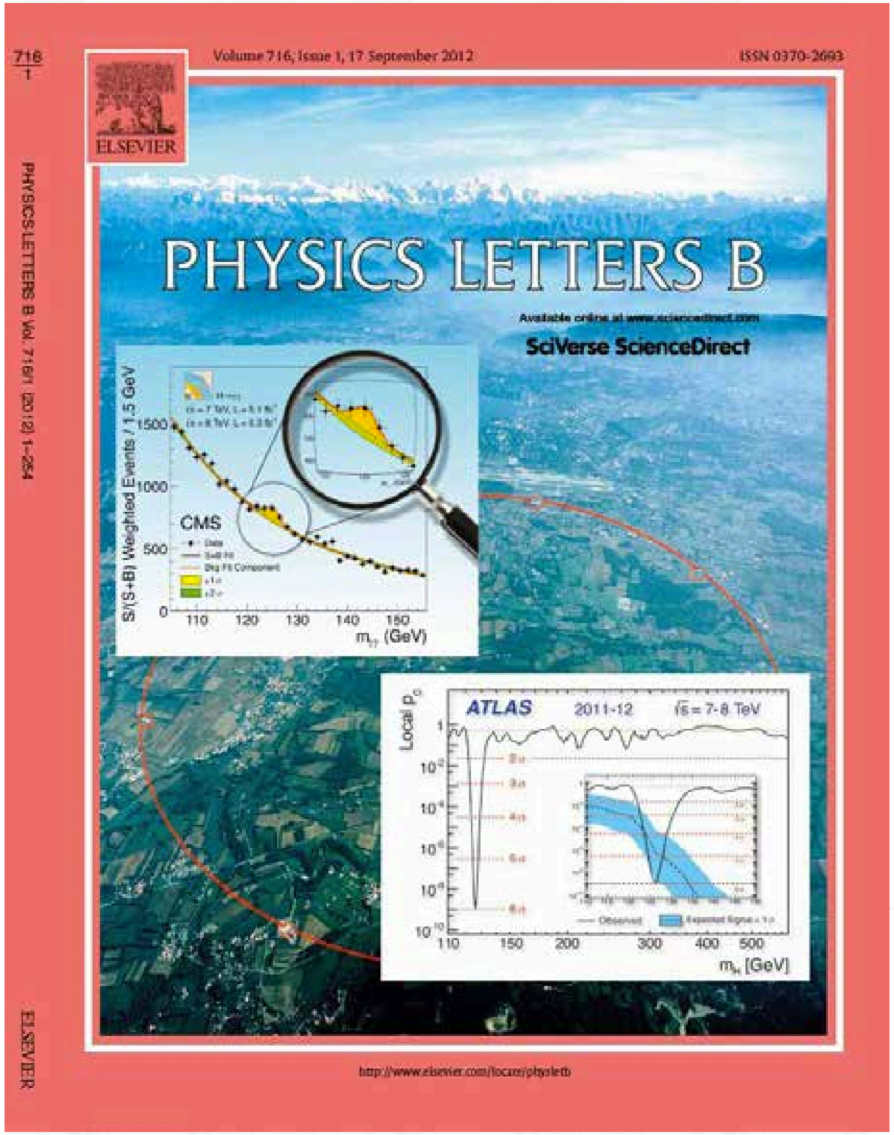




Small probabilitie... ...ackground-only hypothesis observed for:

ATLAS: 1... ...GeV: 5.9σ (expected for m_H = 126.0 GeV: 5.0 σ)

CMS: ...5.3 GeV: : 5.0σ (expected for m_H = 125.3 GeV: 5.8 σ)



Physics Letters B

Volume 716, Issue 1, 17 September 2012, Pages 1–29

Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC ☆

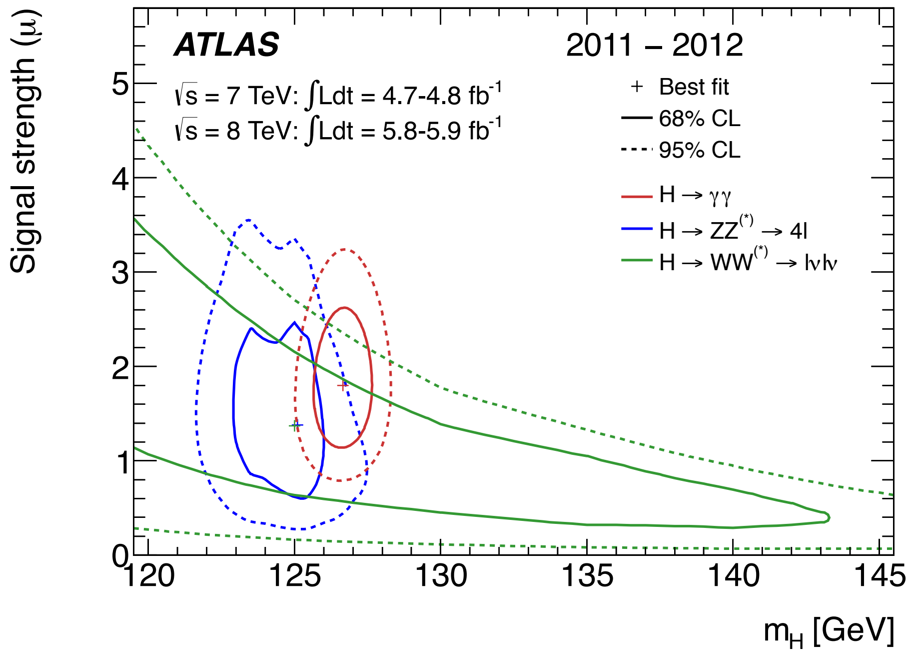
Universally Available

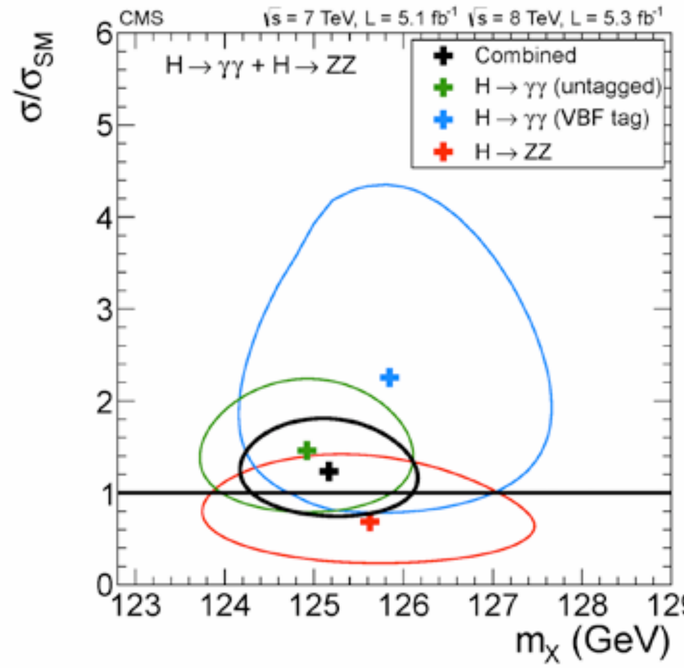
This paper is dedicated to the memory of our ATLAS colleagues who did not live to see the full impact and significance of their contributions to the experiment.

ATLAS Collaboration*

G. Aad[48], T. Abajyan[21], B. Abbott[111], J. Abdallah[12], S. Abdel Khalek[115], A.A. Abdelalim[49], O. Abdinov[11], R. Aben[105], B. Abi[112], M. Abolins[88], O.S. AbouZeid[158], H. Abramowicz[153], H. Abreu[136], B.S. Acharya[164a, 164b], L. Adamczyk[38], D.L. Adams[25], T.N. Addy[56], J. Adelman[176], S. Adomeit[98], P. Adragna[75], T. Adye[129], S. Aefsky[23], J.A. Aguilar-Saavedra[124b, a], M. Agustoni[17], M. Aharrouche[81], S.P. Ahlen[22], F. Ahles[48], A. Ahmad[148], M. Ahsan[41], G. Aielli[133a, 133b], T. Akdogan[19a], T.P.A. Åkesson[79], G. Akimoto[155], A.V. Akimov[94], M.S. Alam[2], M.A. Alam[76], J. Albert[169], S. Albrand[55], M. Aleksa[30], I.N. Aleksandrov[64], F. Alessandria[89a], C. Alexa[26a], G. Alexander[153], G. Alexandre[49], T. Alexopoulos[10], M. Alhroob[164a, 164c], M. Aliev[16], G. Alimonti[89a], J. Alison[120], B.M.M. Allbrooke[18], P.P. Allport[73], S.E. Allwood-Spiers[53], J. Almond[82], A. Aloisio[102a, 102b], R. Alon[172], A. Alonso[79], F. Alonso[70], A. Altheimer[35], B. Alvarez Gonzalez[88], M.G. Alviggi[102a, 102b], K. Amako[65], C. Amelung[23], V.V. Ammosov[128, *], S.P. Amor Dos Santos[124a], A. Amorim[124a, b], N. Amram[153], C. Anastopoulos[30], L.S. Ancu[17], N. Andari[115], T. Andeen[35], C.F. Anders[58b], G. Anders[58a], K.J. Anderson[31], A. Andreazza[89a, 89b], V. Andrei[58a], M.-L. Andrieux[55], X.S. Anduaga[70], S. Angelidakis[9], P. Anger[44], A. Angerami[35], F. Anghinolfi[30], A. Anisenkov[107], N. Anjos[124a], A. Annovi[47], A. Antonaki[9], M. Antonelli[47], A. Antonov[96], J. Antos[144b], F. Anulli[132a], M. Aoki[101], S. Aoun[83], L. Aperio Bella[5], R. Apolle[118, c], G. Arabidze[88], I. Aracena[143], Y. Arai[65], A.T.H. Arce[45], S. Arfaoui[148], J.-F. Arguin[93], E. Arik[19a, *], M. Arik[19a], A.J. Armbruster[87], O. Arnaez[81], V. Arnal[80], C. Arnault[115], A. Artamonov[95], G. Artoni[132a, 132b], D. Arutinov[21], S. Asai[155], S. Ask[28], B. Åsman[146a, 146b], L. Asquith[6], K. Assamagan[25], A. Astbury[169], M. Atkinson[165], B. Aubert[5], E. Auge[115], K. Augsten[127], M. Aurousseau[145a], G. Avolio[163], R. Avramidou[10], D. Axen[168], G. Azuelos[93, d], Y. Azuma[155], M.A. Baak[30], G. Baccaglioni[89a], C. Bacci[134a, 134b], A.M. Bach[15], H. Bachacou[136], K. Bachas[30], M. Backes[49], M. Backhaus[21], J. Backus Mayes[143], E. Badescu[26a], P. Bagnaia[132a, 132b], S. Bahinipati[3], Y. Bai[33a], D.C. Bailey[158], T. Bain[158], J.T. Baines[129], O.K. Baker[176], M.D. Baker[25], S. Baker[77], P. Balek[126], E. Banas[39], P. Banerjee[93], Sw. Banerjee[173], D. Banfi[30], A. Bangert[150], V. Bansal[169], H.S. Bansil[18], L. Barak[172], S.P. Baranov[94], A. Barbaro Galtieri[15], T. Barber[48], E.L. Barberio[86], D. Barberis[50a, 50b], M. Barbero[21], D.Y. Bardin[64], T. Barillari[99], M. Barisonzi[175], T. Barklow[143], N. Barlow[28], B.M. Barnett[129], R.M. Barnett[15], A. Baroncelli[134a], G. Barone[49], A.J. Barr[118], F. Barreiro[80], J. Barreiro Guimarães da Costa[57], P. Barrillon[115], R. Bartoldus[143], A.E. Barton[71], V. Bartsch[149], A. Basye[165], R.L. Bates[53], L.

Determination of mass and signal strength



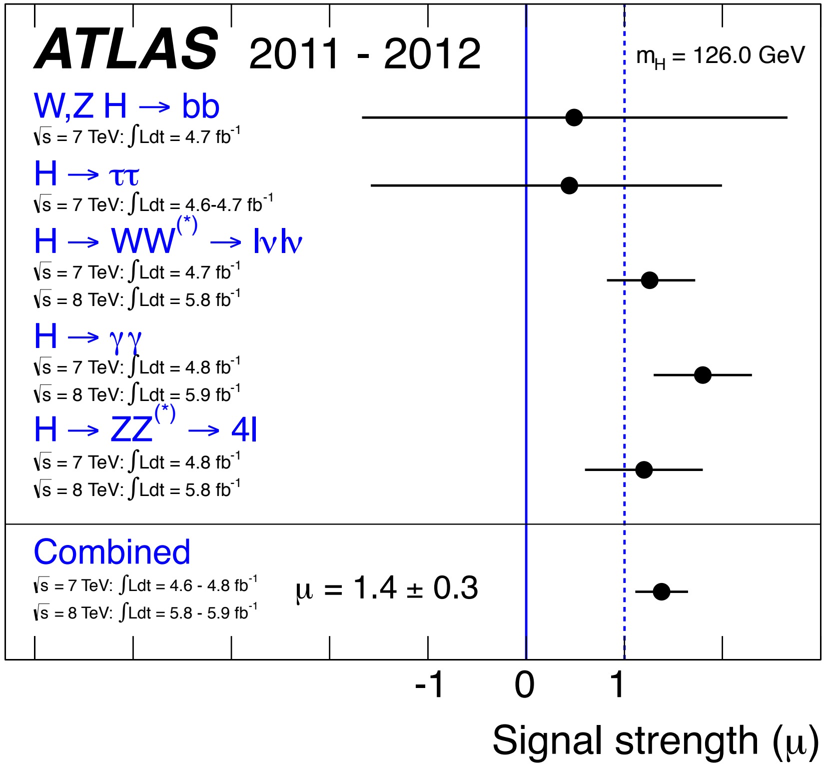


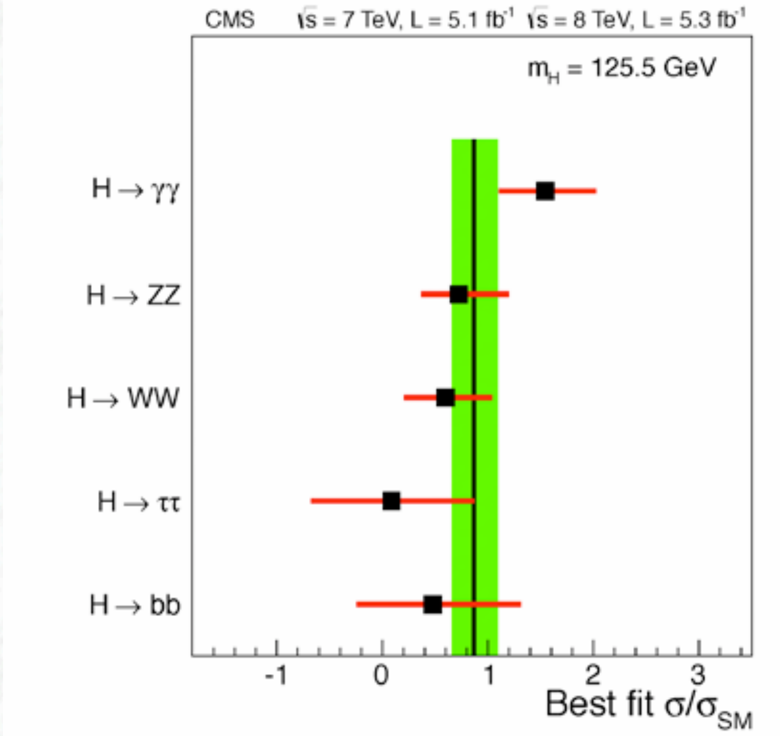
m_H = 126.0 ± 0.4 (stat) ± 0.4 (syst) GeV

m_H = 125.3 ± 0.4 (stat) ± 0.5 (syst) GeV

Is it the Standard Model Higgs boson ?

First indication from the signal strengths in the individual channels, normalized to the Standard Model expectations





- Data are consistent with the hypothesis of a Standard Model Higgs boson !
- Experimental uncertainties are still too large to get excited about "high" γγ and "low" fermionic (ττ and bb) signal strength !

Next important steps:

- Updated analyses awaited for the “Hadron Collider Physics” Conference in Kyoto in November

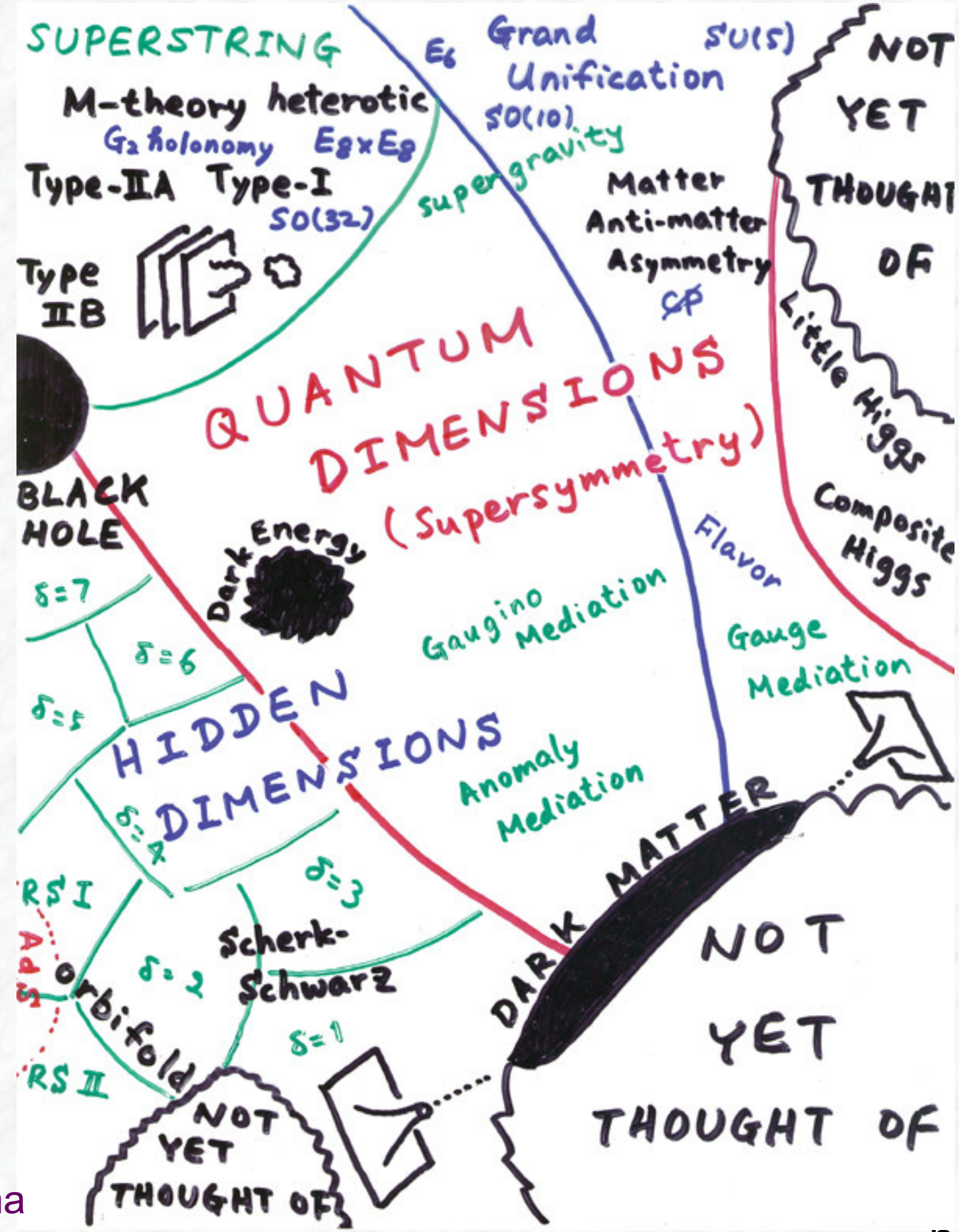
  In particular more complete results from ATLAS on $\tau\tau$ and bb channels expected

- Maybe first glimpses at spin of the resonance

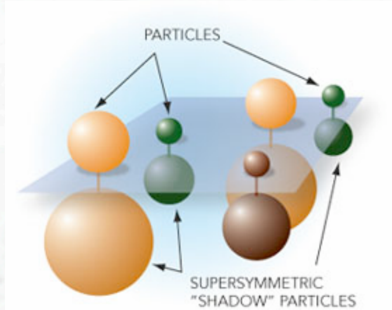
Part 5: Searches for Physics Beyond the Standard Model

- A few examples from SUSY searches

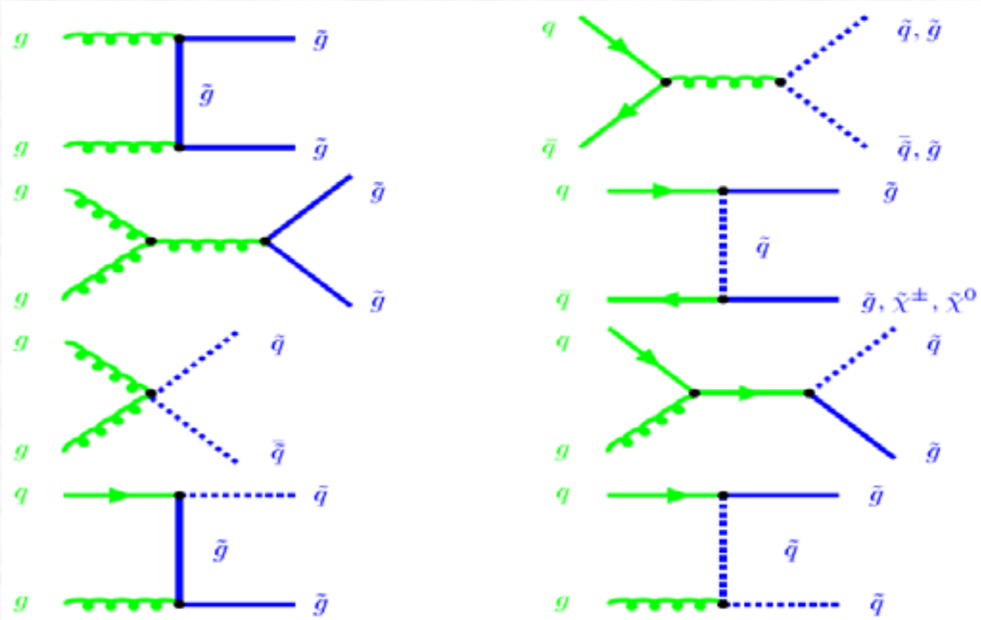
- Some Exotics



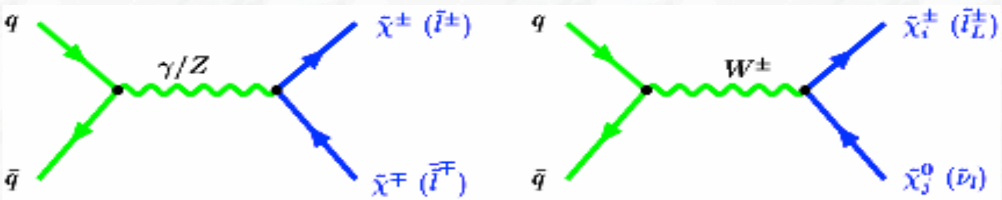
5.1 Search for Supersymmetry



- qq, qg or gg in the initial state → production of coloured SUSY particles is dominant, via strong interaction

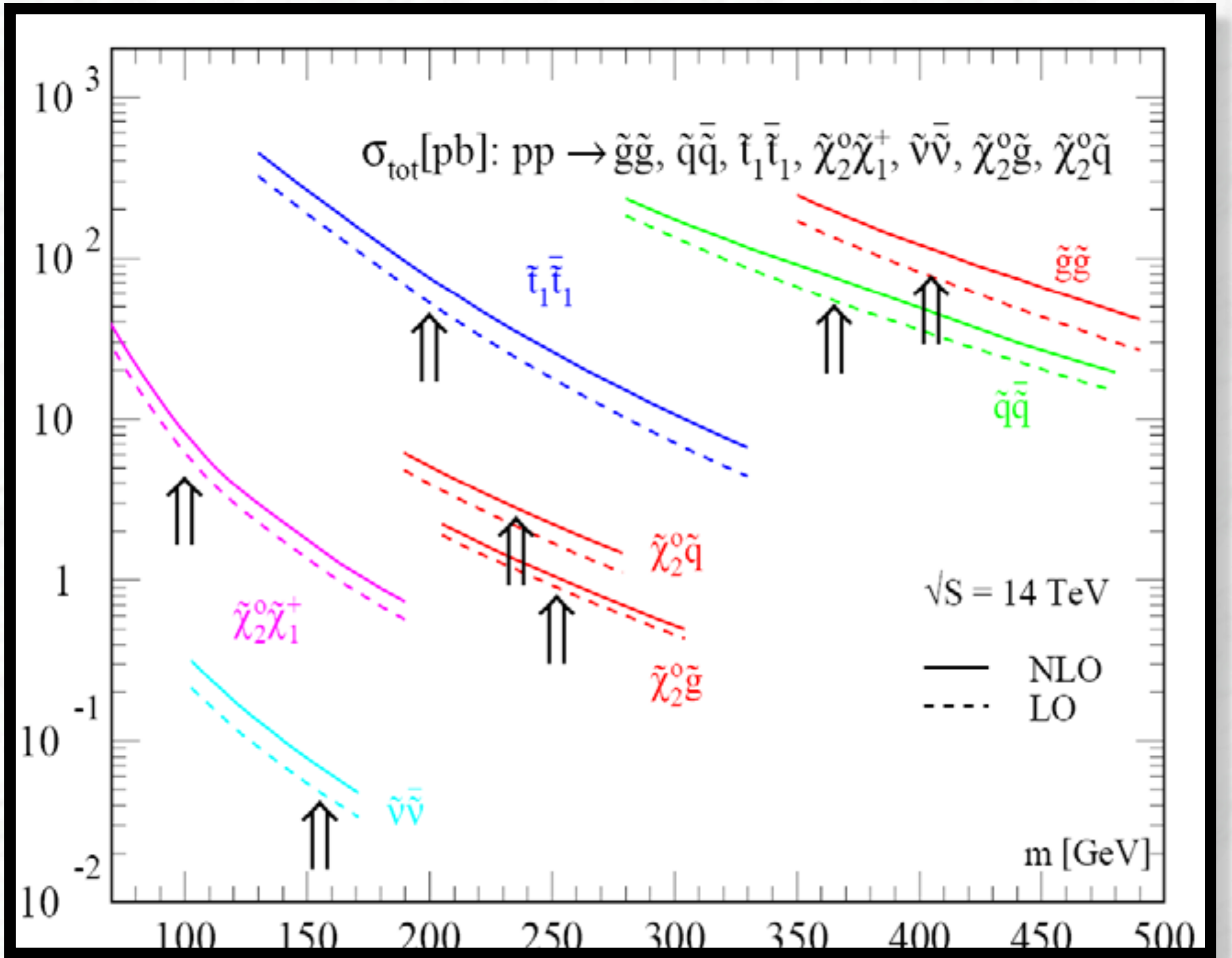


- Drell-Yan production of sleptons, charginos and neutralinos (lower cross sections)



Cross sections for SUSY production processes

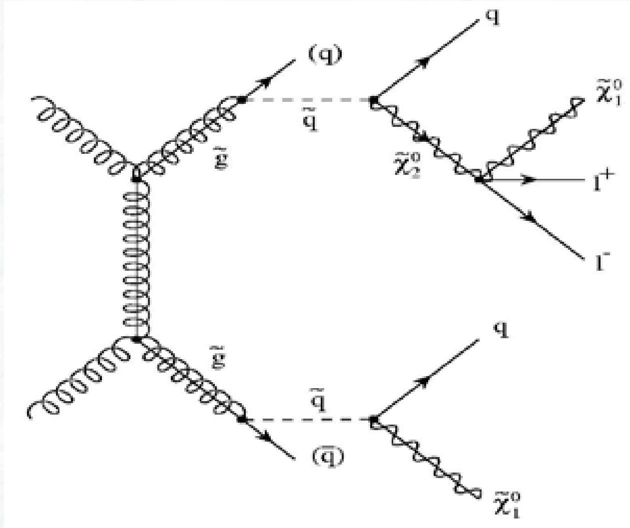
σ (pb)



M (GeV)

NLO corrections in QCD perturbation theory are known

Search for squarks and gluinos

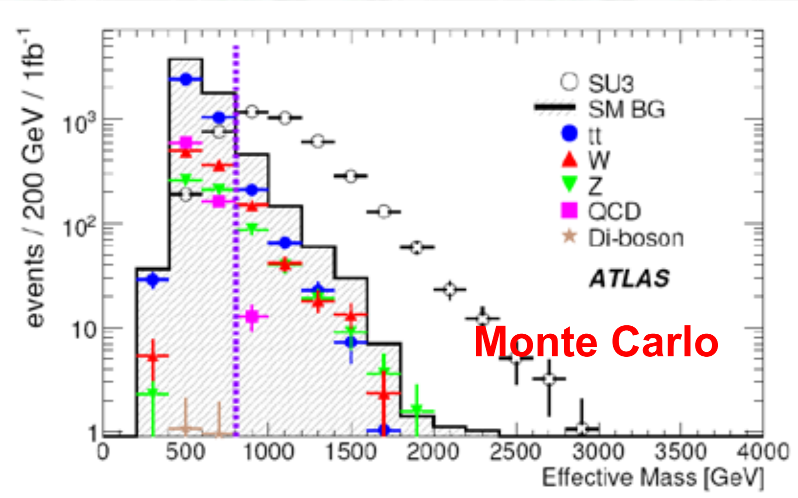


- If R-parity conserved, cascade decays produce distinctive events:

  multiple jets, leptons, and E_T^{miss}

- Typical selection: $N_{jet} > 4$, $E_T > 100, 50, 50, 50$ GeV,
  $E_T^{miss} > 100$ GeV

- Define: $M_{eff} = E_T^{miss} + P_T^1 + P_T^2 + P_T^3 + P_T^4$ (effective mass)



example: mSUGRA, point SU3 (bulk region)
m_0 = 100 GeV, $m_{1/2}$ = 300 GeV
tan β = 6, A_0 = -300 GeV, $\mu > 0$

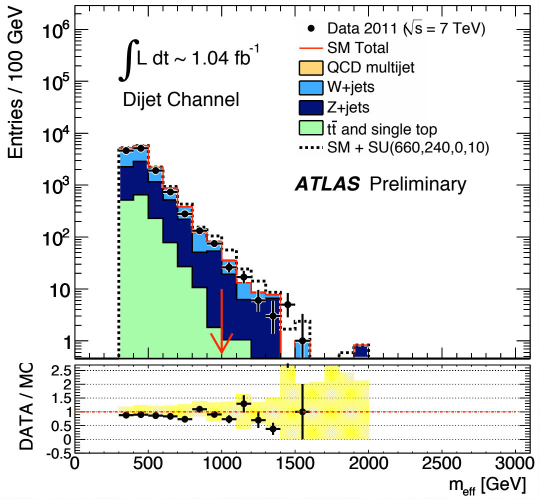
What do the data say ?

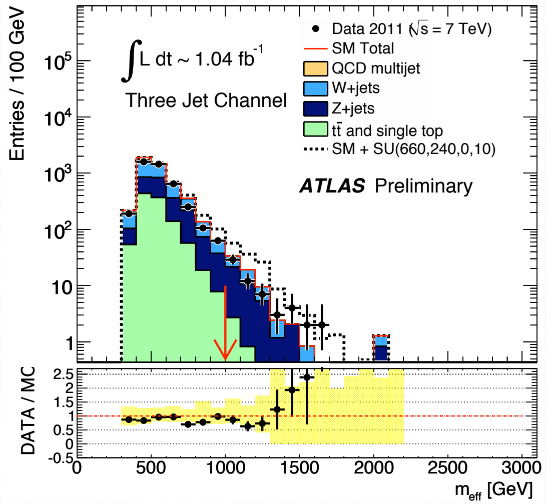
Process	Signal Region				
	≥ 2-jet	≥ 3-jet	≥ 4-jet, $m_{\rm eff}$ > 500 GeV	≥ 4-jet, $m_{\rm eff}$ > 1000 GeV	High mass
Z/γ+jets	32.5 ± 2.6 ± 6.8	25.8 ± 2.6 ± 4.9	208 ± 9 ± 37	16.2 ± 2.1 ± 3.6	3.3 ± 1.0 ± 1.3
W+jets	26.2 ± 3.9 ± 6.7	22.7 ± 3.5 ± 5.8	367 ± 30 ± 126	12.7 ± 2.1 ± 4.7	2.2 ± 0.9 ± 1.2
$t\bar{t}$+ Single Top	3.4 ± 1.5 ± 1.6	5.6 ± 2.0 ± 2.2	375 ± 37 ± 74	3.7 ± 1.2 ± 2.0	5.6 ± 1.7 ± 2.1
QCD jets	0.22 ± 0.06 ± 0.24	0.92 ± 0.12 ± 0.46	34 ± 2 ± 29	0.74 ± 0.14 ± 0.51	2.10 ± 0.37 ± 0.83
Total	62.3 ± 4.3 ± 9.2	55 ± 3.8 ± 7.3	984 ± 39 ± 145	33.4 ± 2.9 ± 6.3	13.2 ± 1.9 ± 2.6
Data	58	59	1118	40	18

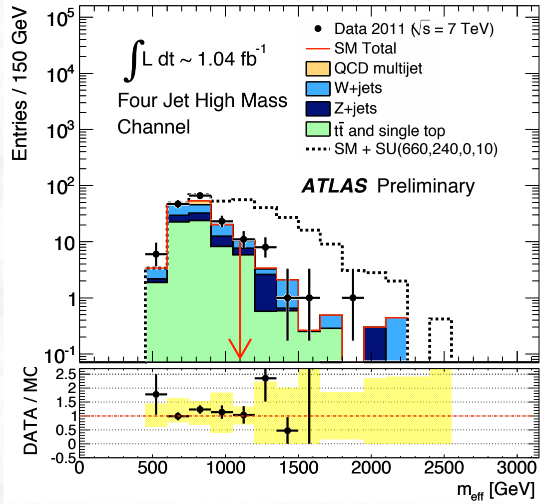
Observed and expected event numbers (from Standard Model processes)

dominant backgrounds:
- W/Z + jets
- tt production

Normalized in control regions !

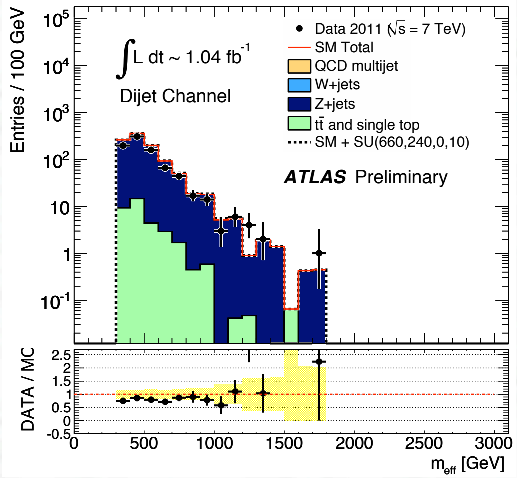


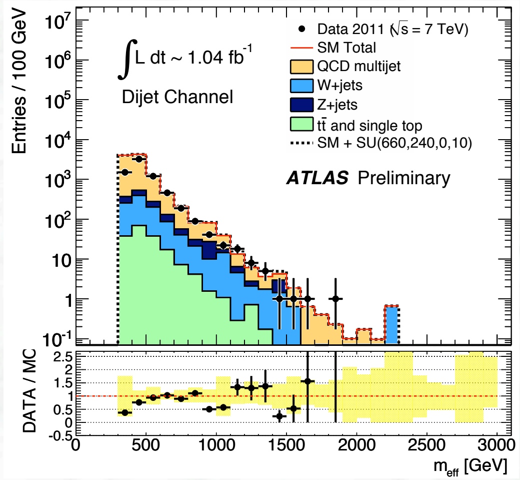




Summary on control of backgrounds using data

(control regions, very important !!)



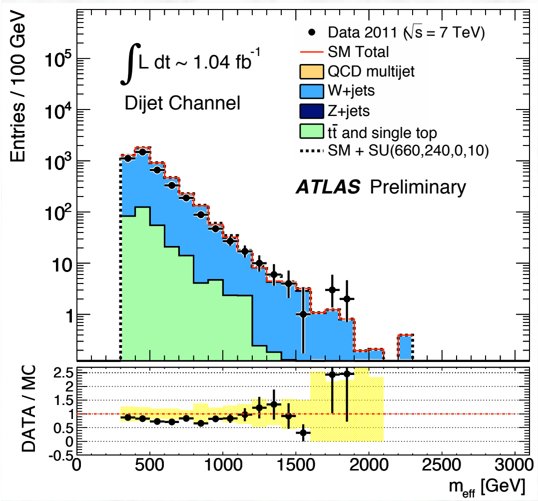


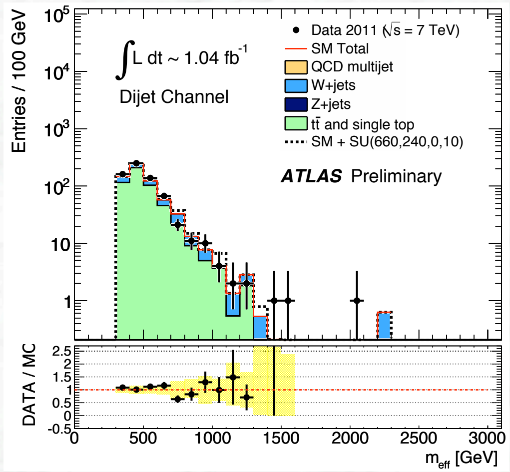
A: Z + jet events, Z → ee

(to estimate Z → $\nu\nu$ background, likewise γ + jet events were used)

B: QCD multijet background

(reverse cut on $\Delta\phi$ (jet, E_T^{miss})





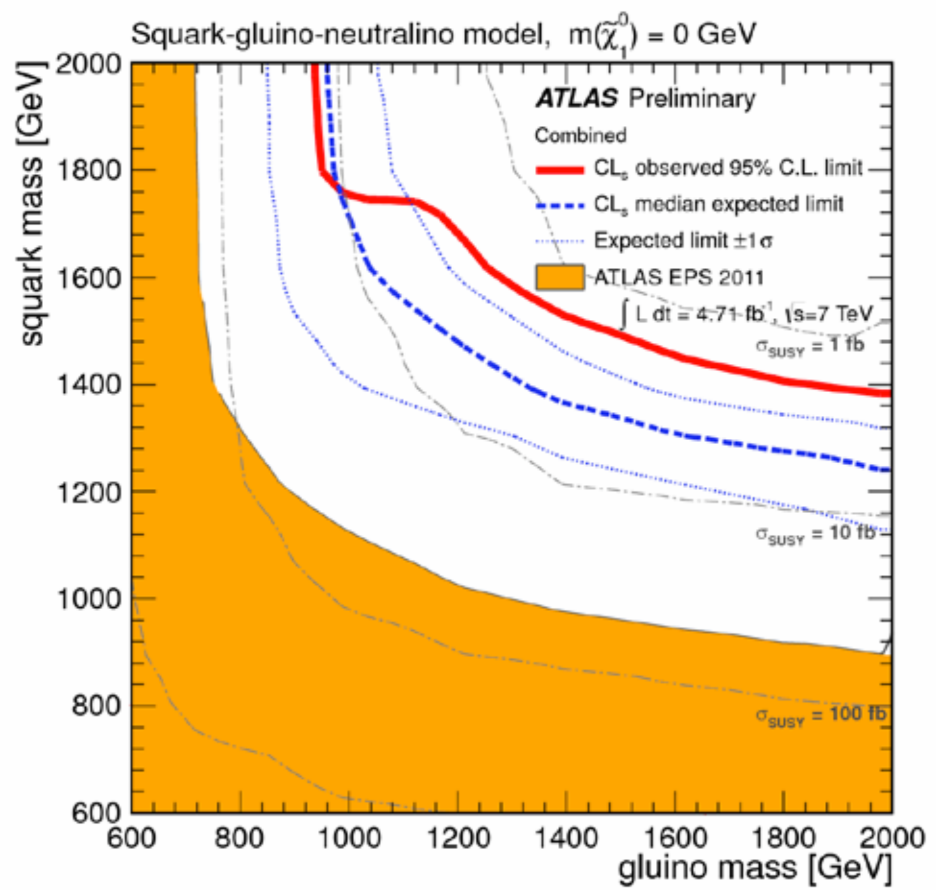
C: W → lν + jet control region

(select events with one lepton,
30 < $M_T(l,E_T^{miss})$ < 100 GeV,
no b-jet to suppress top contribution)

D: top quark control region

(same selection as for W events,
but require b-tag)

Results from 2011 data, 4.7 fb^{-1}

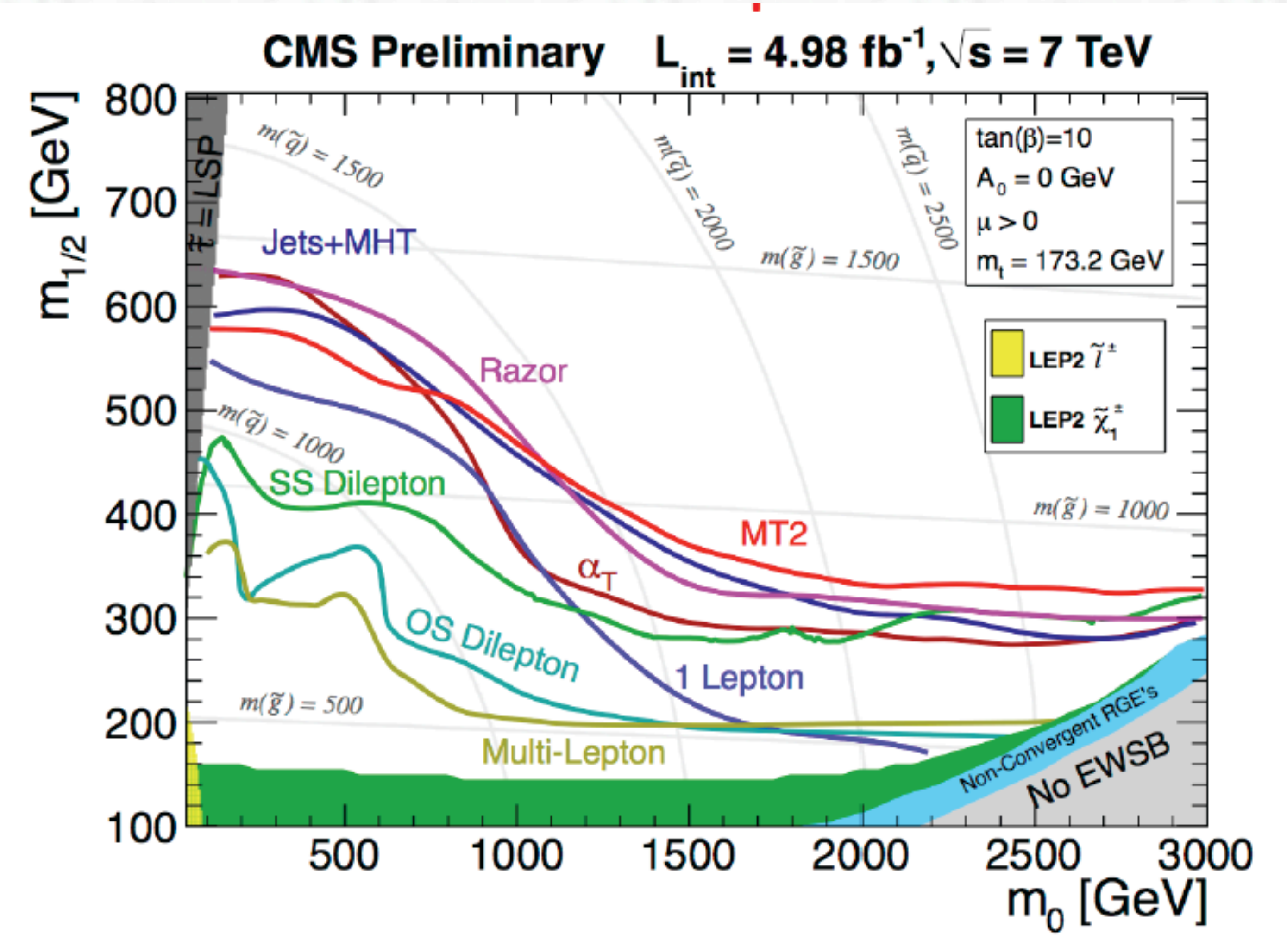


Interpretation of the results in the (m_{gluino}, m_{squark})-plane as 95% C.L. exclusion limits in a simplified SUSY model:

- $m_\chi = 0$
- masses of gluinos and of 1st and 2nd generation squarks as given on plot
- all other SUSY masses are assumed to be decoupled, with masses of 5 TeV

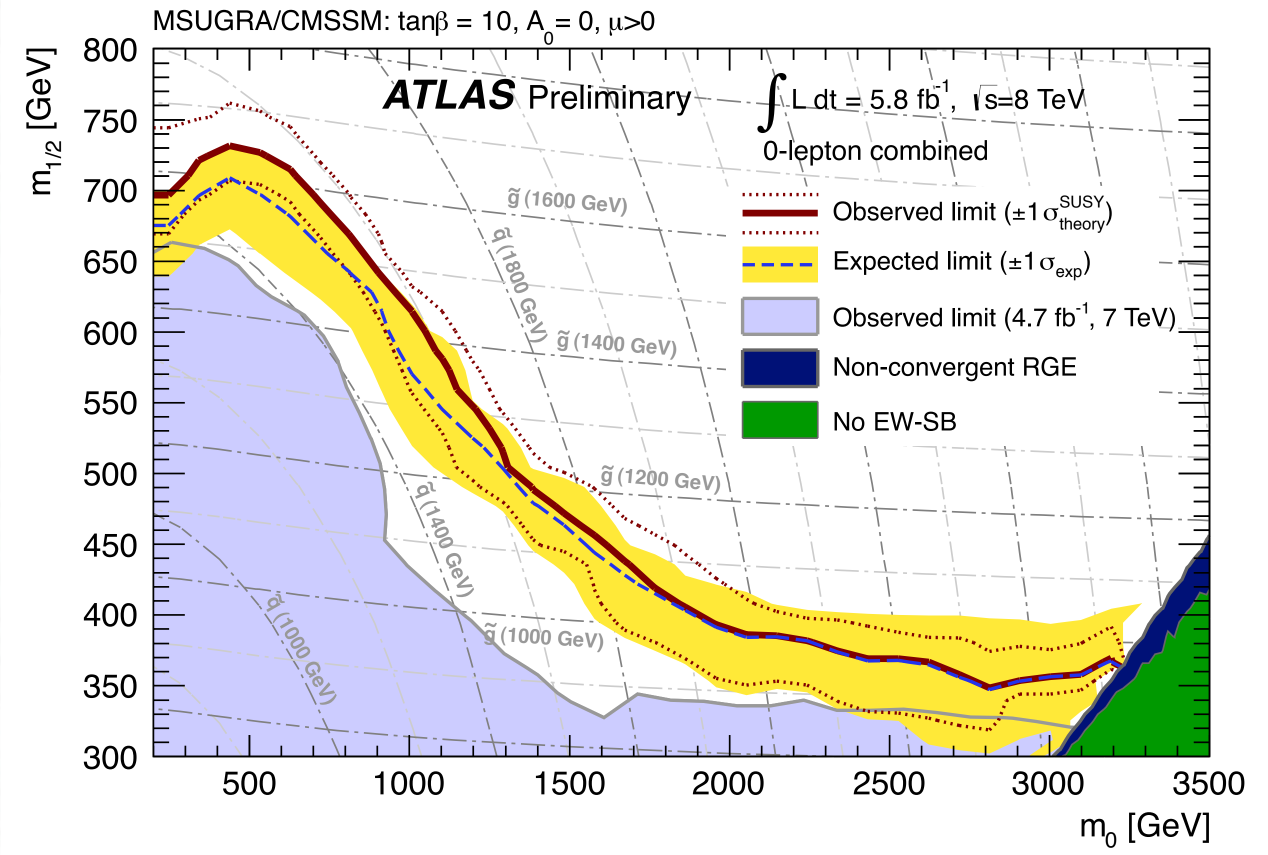
Large area of mass combinations excluded;
Limits do not apply to stop / sbottom production

mSUGRA interpretation



tan β = 10,
A_0 = 0, μ > 0

mSUGRA interpretation, including 2012 data



$\tan\beta = 10$,
$A_0 = 0$, $\mu > 0$

MSSM/cMSSM interpretation (for equal squark and gluino masses):

L = 5.8 fb^{-1} at $\sqrt{s}$ = 8 TeV   m(squark), m(gluino) > 1500 GeV

Looking for “natural” SUSY

- Search for stops and sbottoms in gluino decays

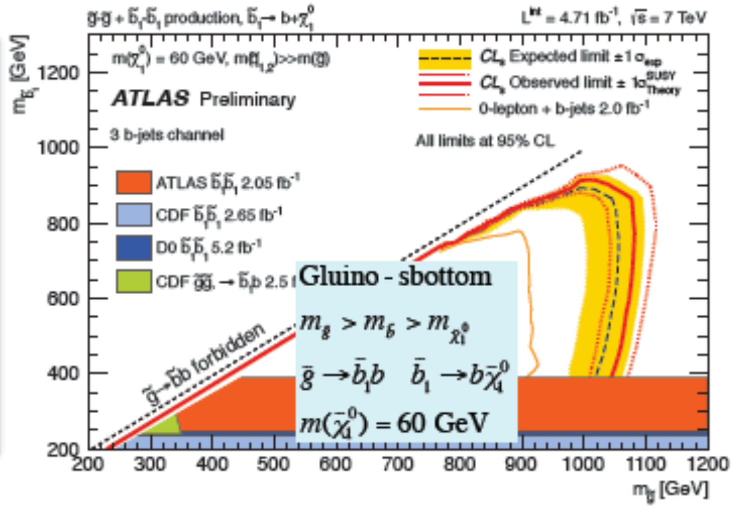
  - If other squarks are very heavy, gluino will decay into sbottoms and stops with high branching ratio

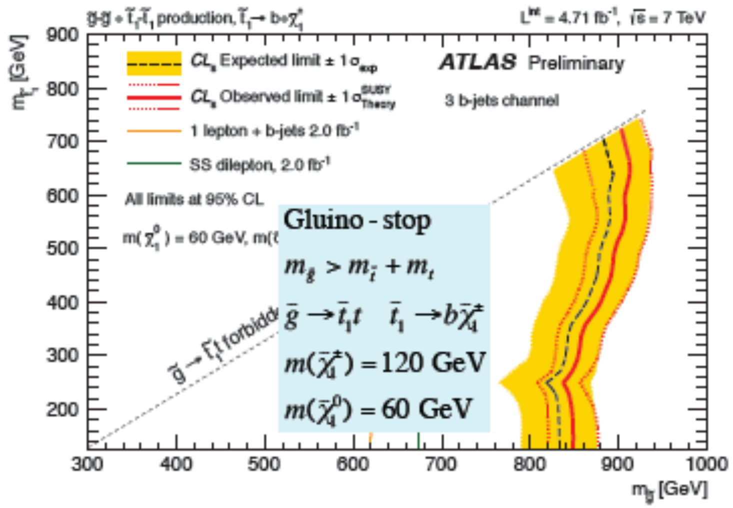
- Search for stop and sbottom pair production
  - to close the loophole that the “gluino is too heavy”

ATLAS: $\tilde{g} \rightarrow \tilde{t}\ ,\tilde{b}$

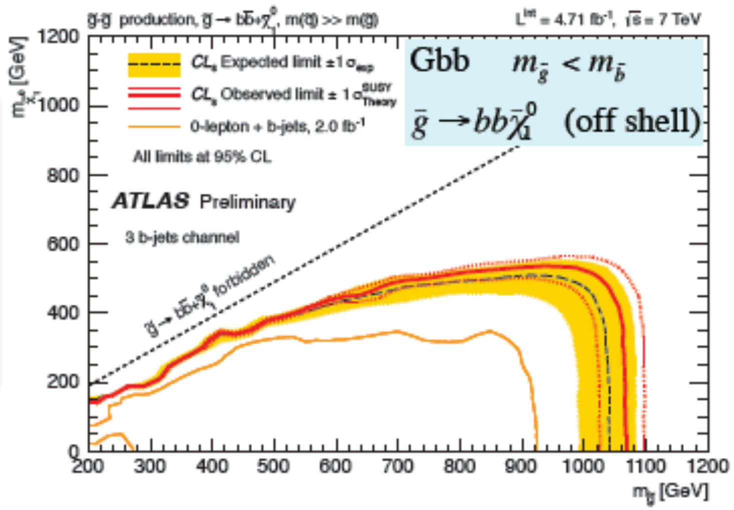
4-6 jets (≥3 b-jets), no leptons. **Allowed decays depend on masses**

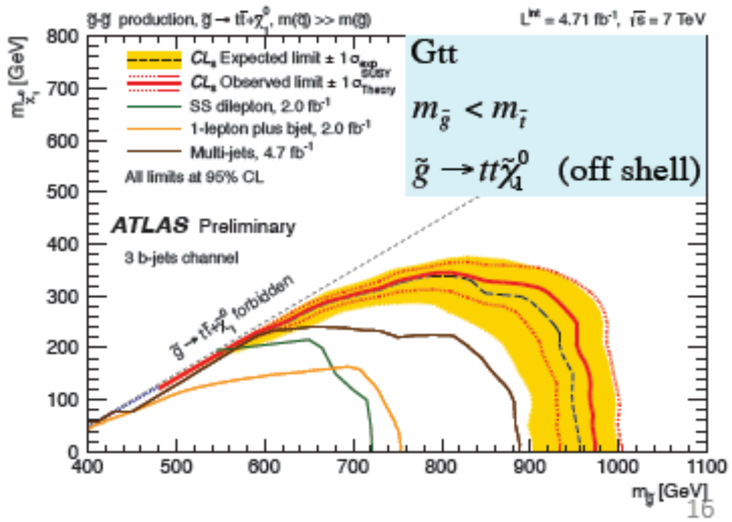
Upper plots – 2-body cascade decays





Lower plots – 3-body decays

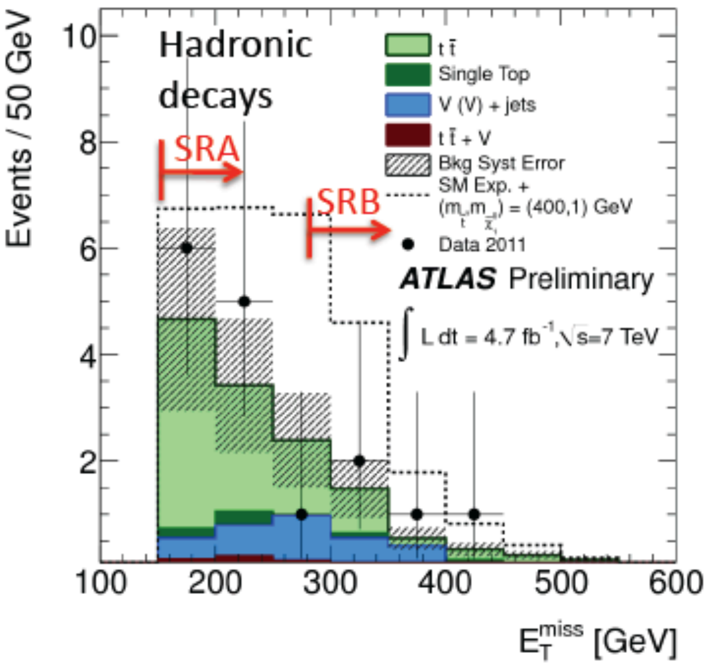




Direct Stop searches

Heavy stop > m_t : look for hadronic or leptonic top decays with extra E_T^{miss}

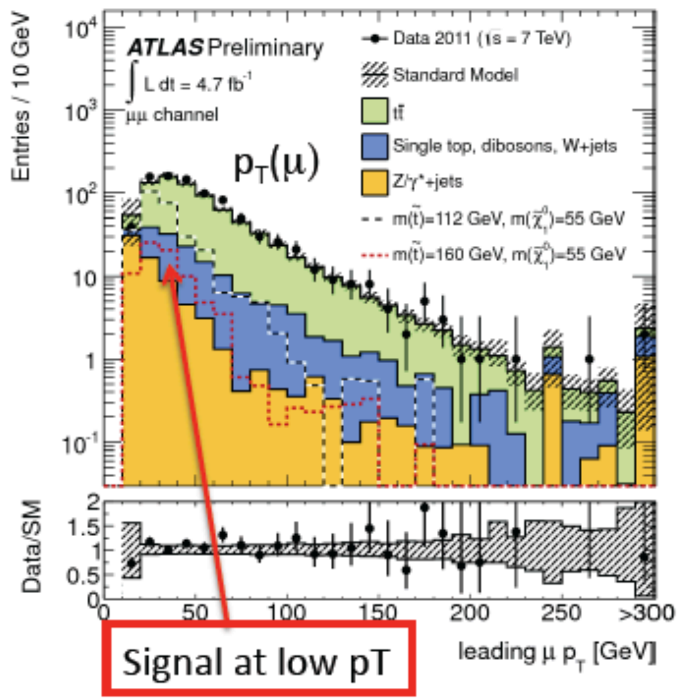
$$\tilde{t}_1 \rightarrow t\,\tilde{\chi}_1^0 \rightarrow Wb\,\tilde{\chi}_1^0$$



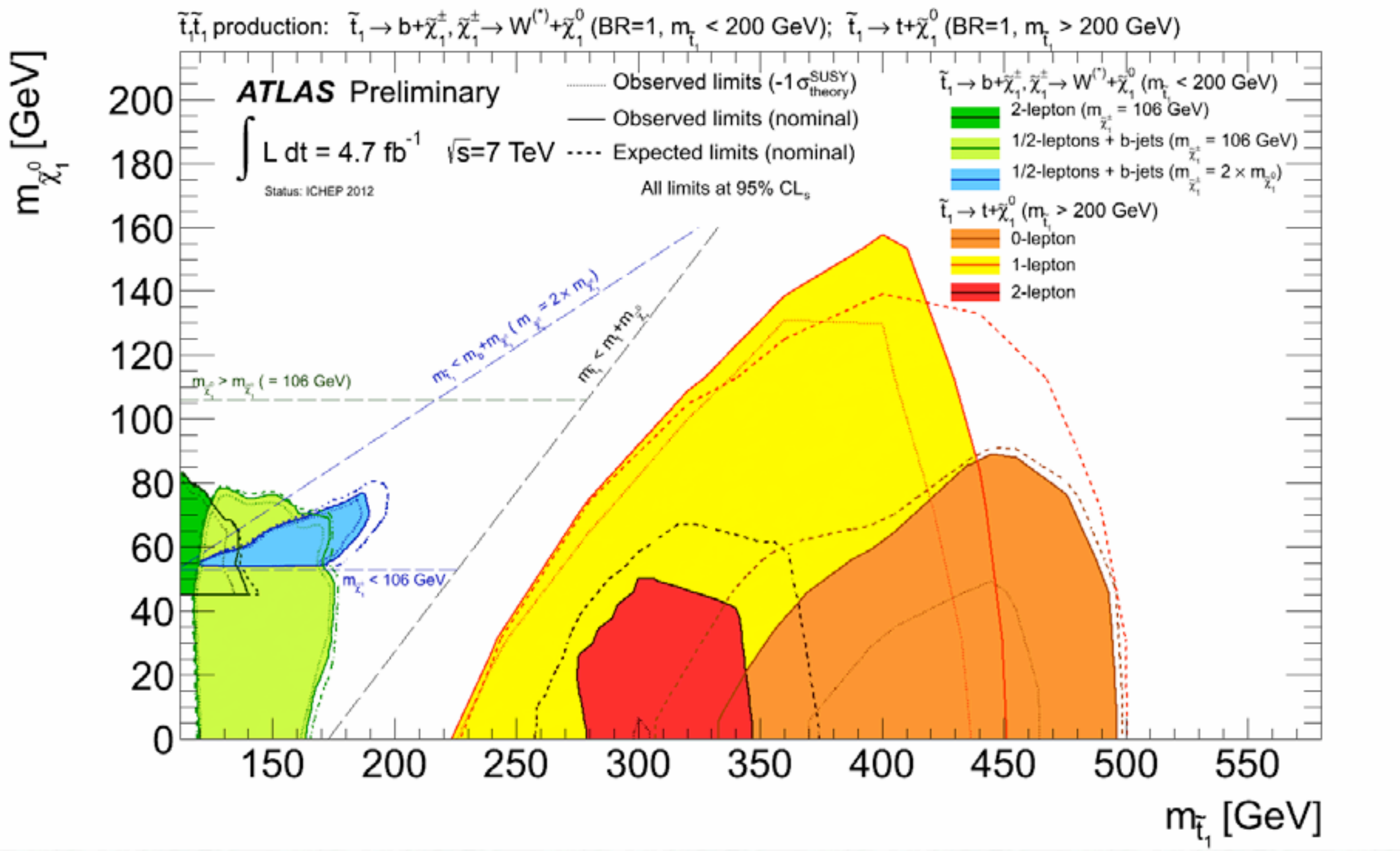
Light stop <m_t : look for top-like decay via chargino. Signal events contain lower p_T leptons, and subsystem mass below $2m_t$

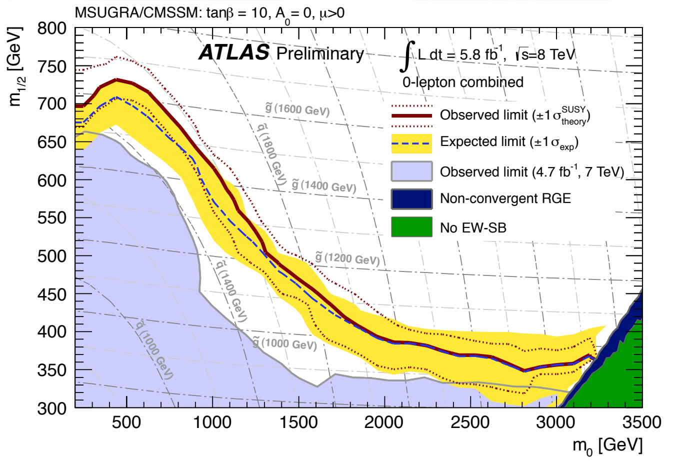
$$m_t > m_{\tilde{t}} > m_{\tilde{\chi}_1^{\pm}}$$

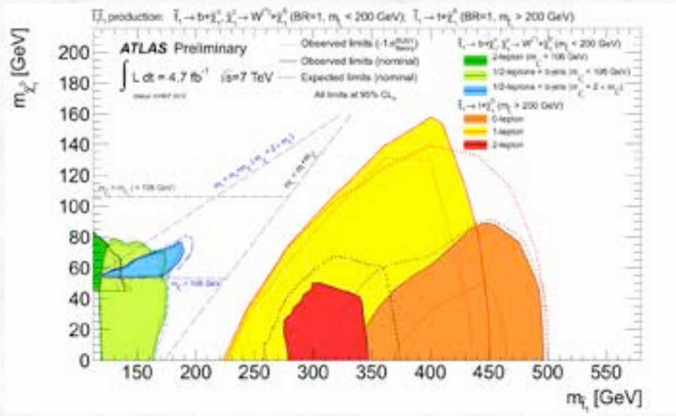
$$\tilde{t} \rightarrow b\,\tilde{\chi}_1^{\pm} \rightarrow bW^{(*)}\tilde{\chi}_1^0$$



Combined stop exclusion







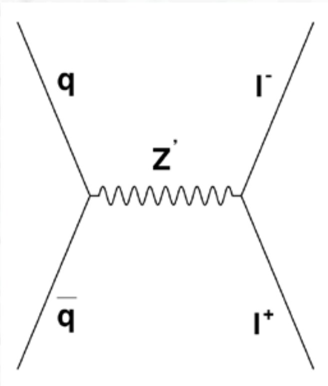
Is SUSY dead ?

A. Parker, ICHEP 2012, SUSY summary talk

- Under attack from all sides, but not dead yet.
- The searches leave little room for SUSY inside the reach of existing data; but interpretations within SUSY models rely on many simplifying assumptions, and so care must be taken when making use of limit plots.
- Plausible “natural” scenarios still not ruled out; Light stop and/or RPV scenarios have few constraints.
- There is no reason to give up hope of finding SUSY at the LHC.

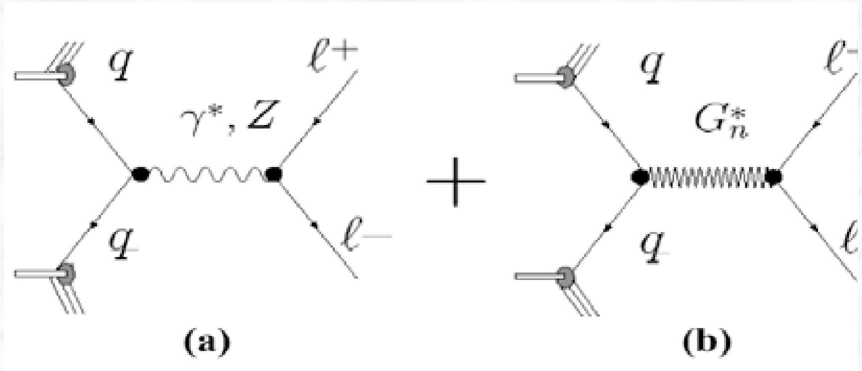
5.2 Search for new, high-mass di-lepton resonances

- Additional neutral Gauge Boson Z´



- Randall-Sundrum narrow Graviton resonances decaying to di-lepton

appear in Extra Dim. Scenarios



Standard Model background process

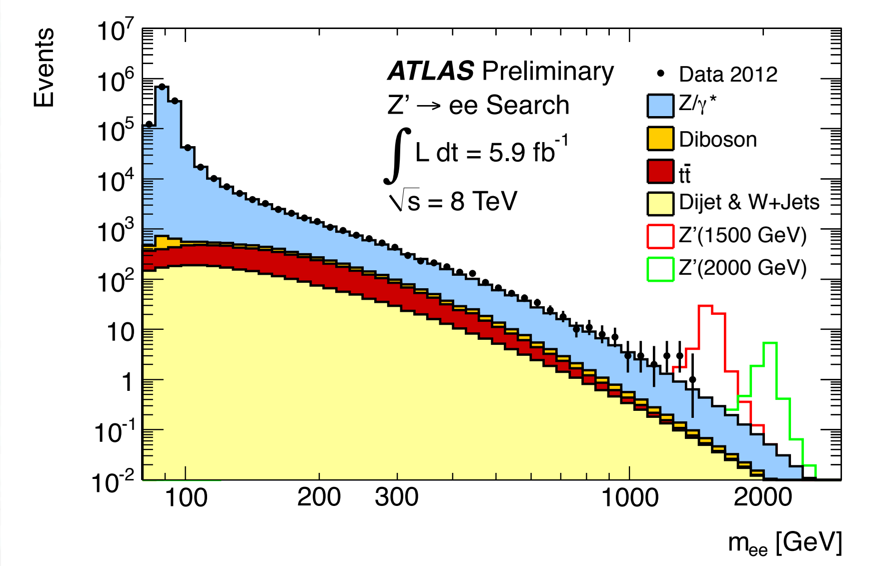
Signal

- Identical final state (two leptons), same analysis, interpretation for different theoretical models
- Main background process: Drell-Yan production of lepton pairs

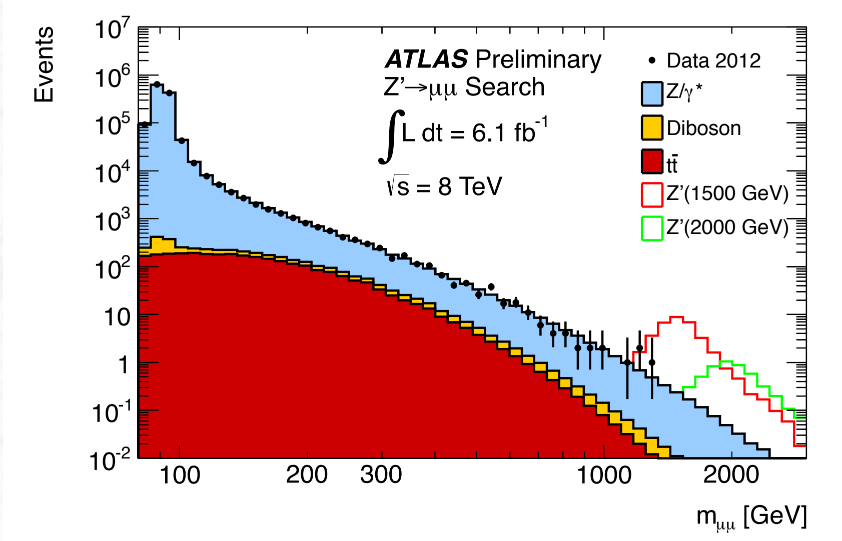
Search for New Resonances in High Mass Di-leptons

2012 data

Di-electron invariant mass



Di-muon invariant mass



Dominant Drell-Yan background has been normalized in the Z peak region, 70-110 GeV

Data are consistent with background from SM processes;

No excess observed.

Z' models used in the interpretation

(i) Sequential Standard Model Z'

- Z' has the same couplings to fermions as the Standard Model Z, width of the Z' increases proportional to its mass

(ii) Models based on the E_6 grand unified symmetry group

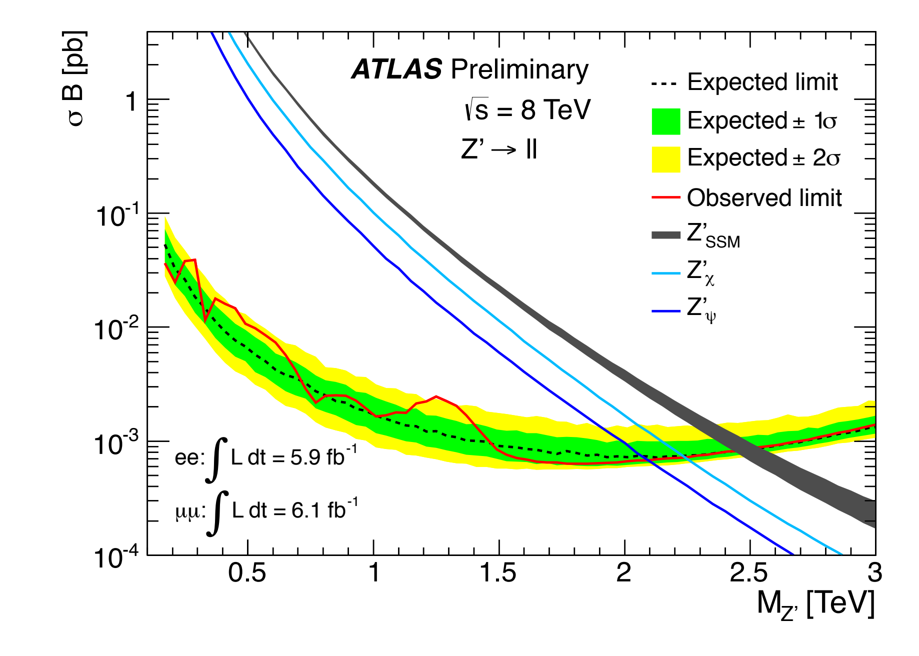
- Broken into SU(5) and two additional U(1) groups, leading to two new neutral gauge fields, denoted Ψ and χ.
  The particles associated with the additional fields can mix to form the Z' candidates

  $Z' = Z'_{\Psi} \cos \theta_{E6} + Z'_{\chi} \sin \theta_{E6}$

- The pattern of symmetry breaking and the value of θ_{E6} determine the Z' couplings to fermions
  (several choices are considered)

Interpretation in the SSM and E6 models:

2012 data



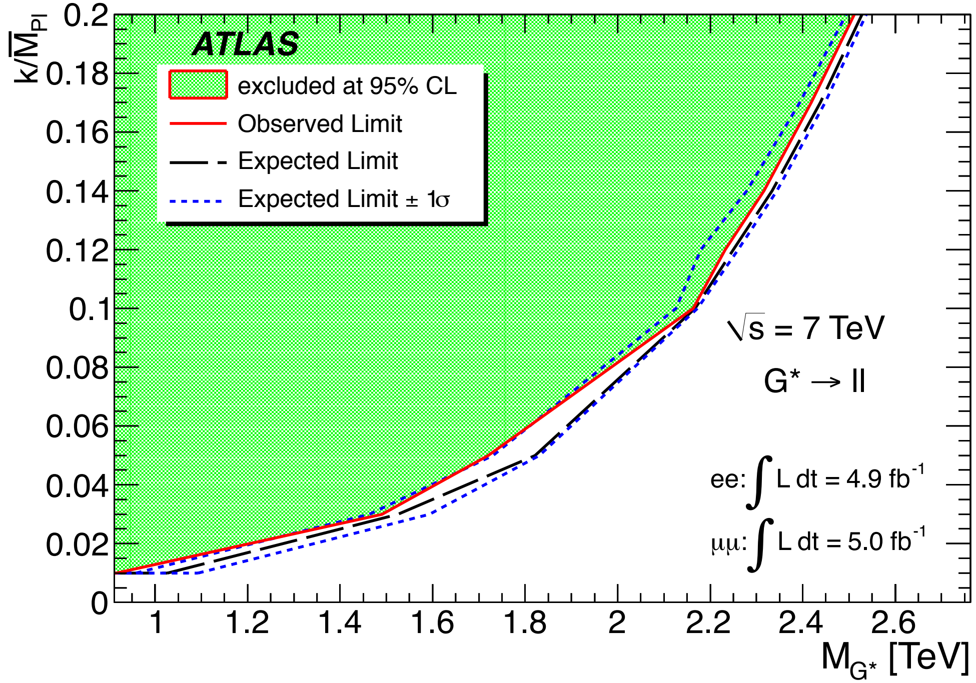
Resulting mass limits: ee + $\mu\mu$
95% C.L.

Sequential SM: $m_{Z'} > 2.49$ TeV
E_6 models: $m_{Z'} > 2.09 - 2.24$ TeV

Summary of 95% C.L. SSM exclusion limits from various experiments:

95% C.L. limits (SM couplings)	ee	$\mu\mu$	ll combined
CDF / D0 5.3 fb^{-1} $\sqrt{s}$ = 1.96 TeV ATLAS 5.9 / 6.1 fb^{-1} $\sqrt{s}$ = 8 TeV CMS 4.1 fb^{-1} $\sqrt{s}$ = 8 TeV	2.39 TeV	2.19 TeV	1.07 TeV 2.49 TeV 2.59 TeV

Interpretation in the Randall-Sundrum models: Graviton resonances: G → ll (Kaluza-Klein modes)



Resulting mass limits: ee + $\mu\mu$
95% C.L.

Limits as a function of the coupling strength k/M'_{Pl}

k : = space-time curvature in the extra dimension
$M'_{Pl} = M_{Pl} / \sqrt{8\pi}$ (reduced Planck scale)

Search for W' → lν

- W': additional charged heavy vector boson

- Appears in theories based on the extension of the gauge group
  e.g. Left-right symmetric models: $SU(2)_R$ W_R

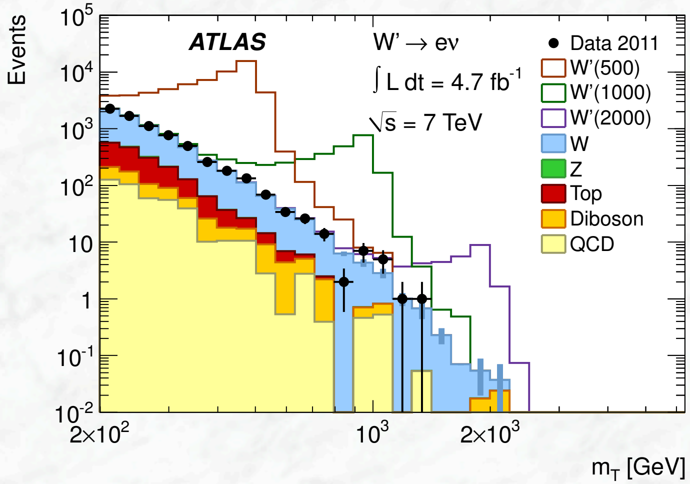
- Assume ν from W' decay to be light and stable, and W' to have the same couplings as in the SM (*"Sequential Standard Model, SSM"*)

Signature: high p_T electron + high E_t^{miss}

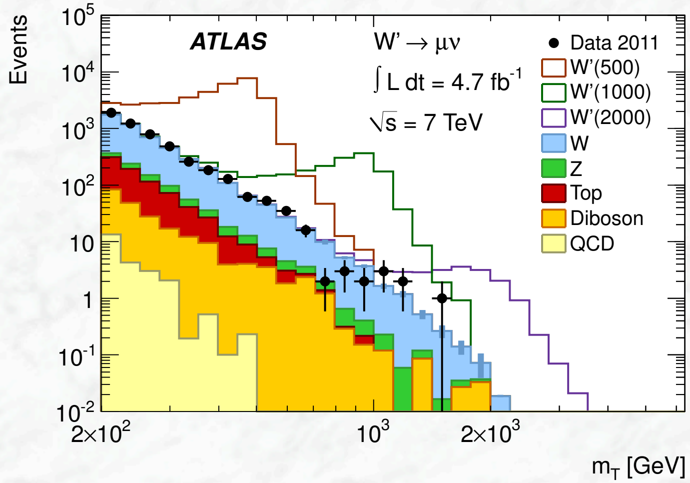
→ peak in transverse mass distribution

Search for New Resonances in High Mass lν events (W')

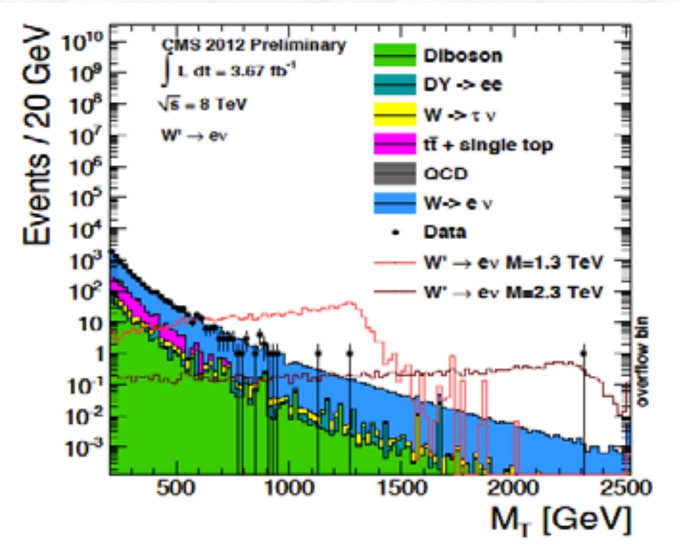
Transverse mass (e, E_T^{miss})

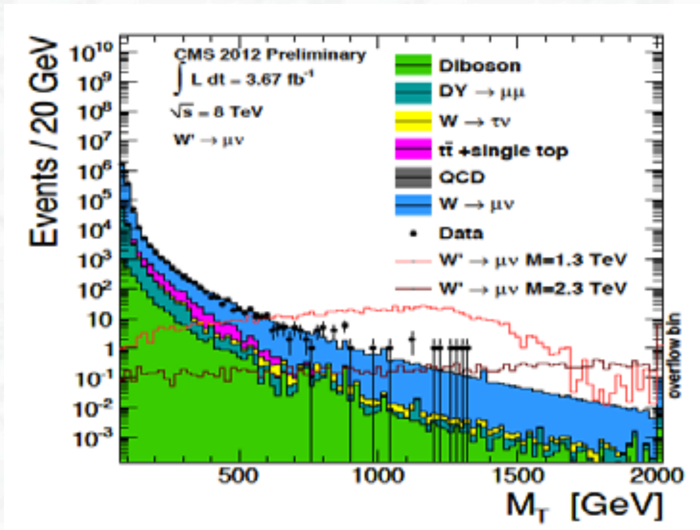


Transverse mass (μ, E_T^{miss})

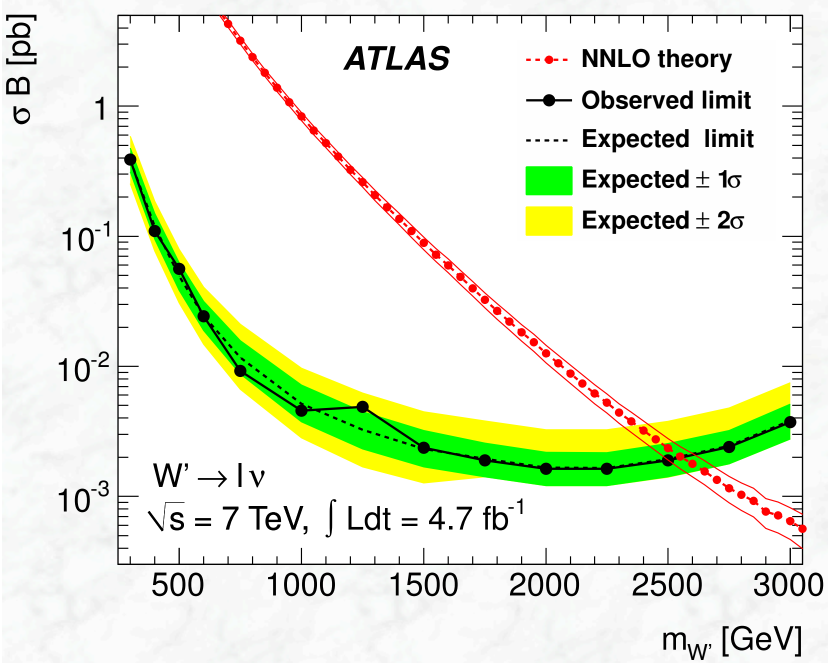


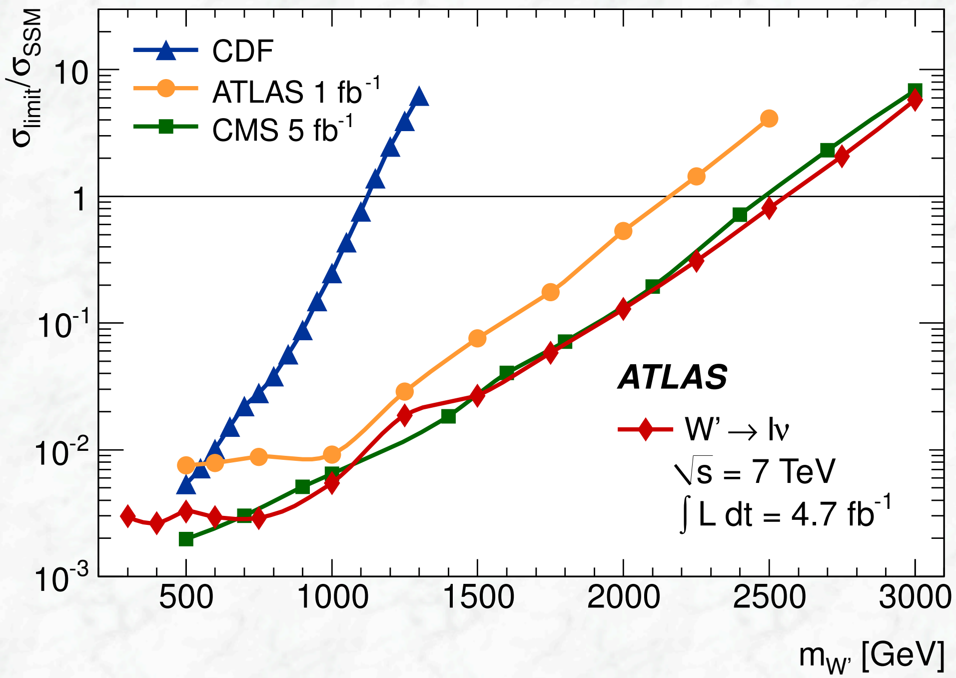
Data are consistent with background from SM processes. No excess observed.





Interpretation in the Sequential SM

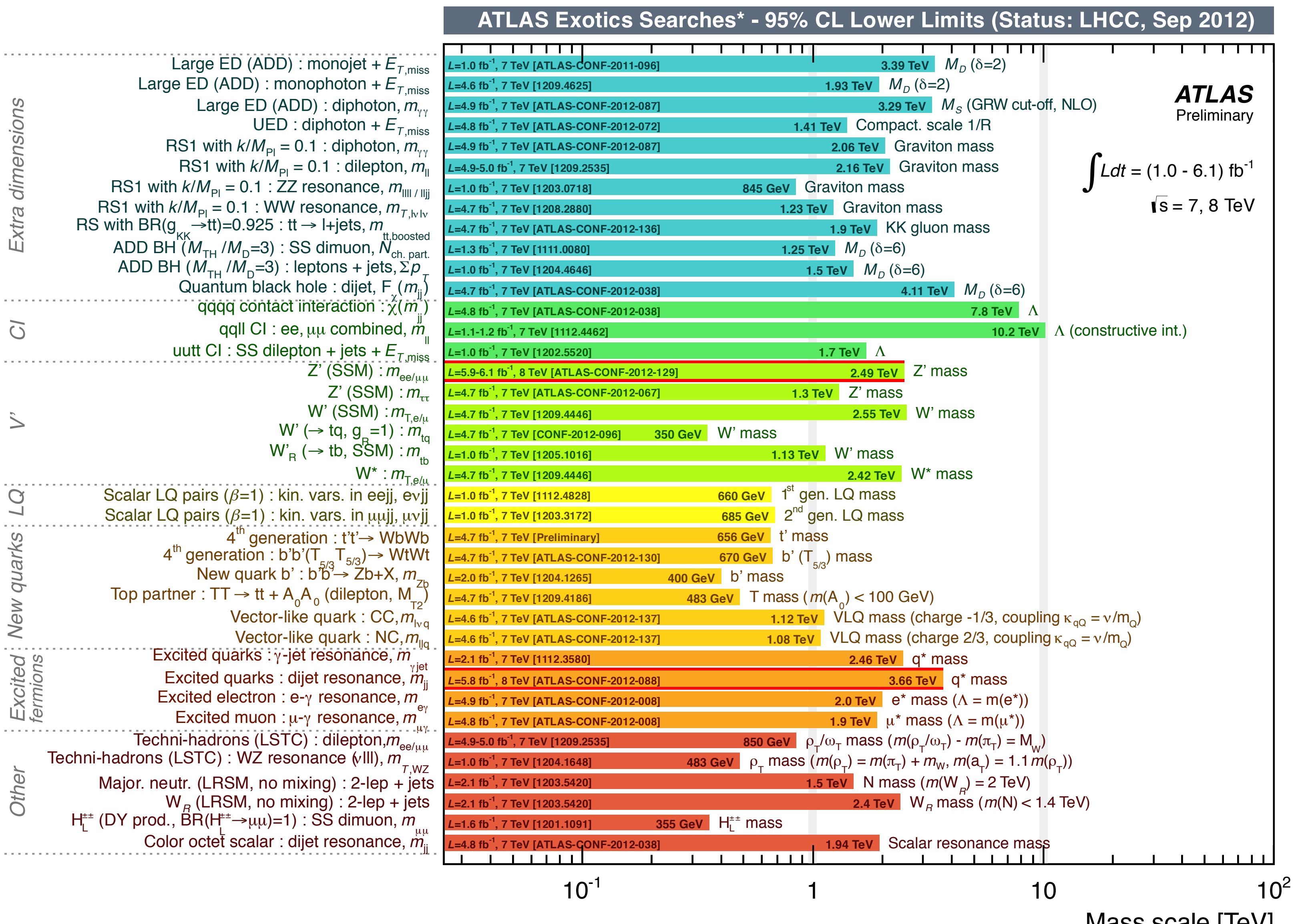




95% C.L. limits (SM couplings)			ll combined
ATLAS	4.7 fb^{-1}	$\sqrt{s}$ = 7 TeV	2.55 TeV
CMS	3.7 fb^{-1}	$\sqrt{s}$ = 8 TeV	2.85 TeV

Summary of 95% C.L. SSM exclusion limits from ATLAS and CMS

Summary of results on searches for Physics Beyond the Standard Model in ATLAS in ATLAS



*Only a selection of the available mass limits on new states or phenomena shown

Summary of the lectures

- After a long way of design, construction, installation, commissioning of both machine and experiments the LHC had an excellent start in 2010
- The performance of the accelerator and the experiments is superb;
  (In 2012: an integrated luminosity > 14 fb^{-1} already)
- The Standard Model has been established, all relevant processes measured;
  In many areas measurements have reached the precision phase
- A new boson has been discovered with a mass around 126 GeV;
  Exiting analyses ahead of us to understand the nature of this new particle
- So far: no deviations from the Standard Model seen, but the LHC potential has by far not yet been fully exploited !