Recent Results from the ATLAS Experiment at LHC

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On behalf of the ATLAS Collaboration

16th Lomonosov Conference on Elementary Particle Physics
21-28 Aug. 2013

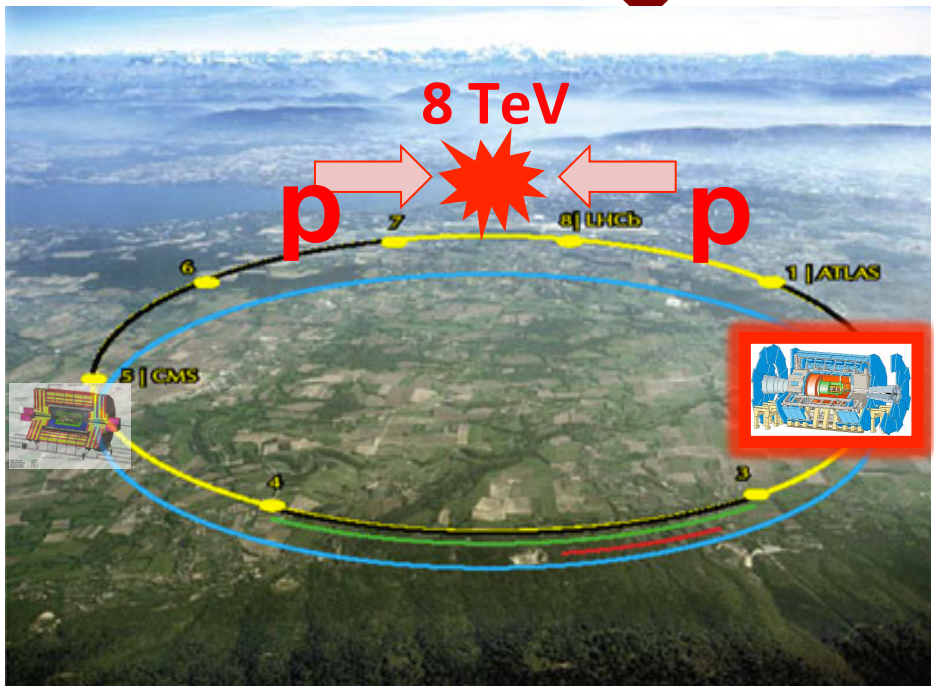
The University of Oklahoma

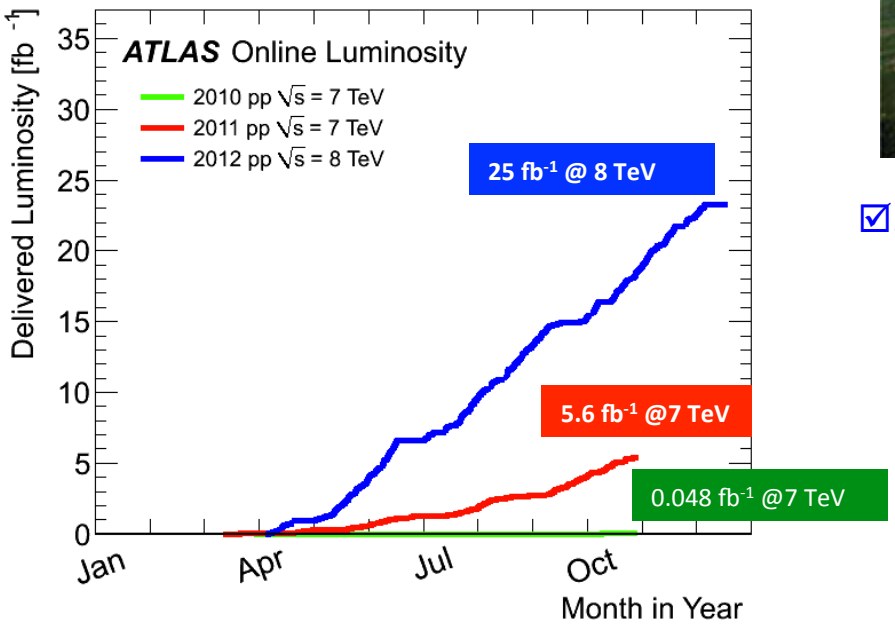
Outline

- ☑ LHC and ATLAS experiment
- ☑ Studies with 7 and 8 TeV C.o.M proton-proton collisions
- ☑ Latest on the Higgs Boson searches
- ☑ Precision measurements and test of Standard Model: Top and Heavy Flavor, diboson,… Well underway….
- ☑ Beyond Standard Model: SUSY, Exotics
- ☑ Future plans for ATLAS physics program

The Tools of Trade (LHC & ATLAS)

- ☑ Operation started end March 2010 @ $\sqrt{s}$=7TeV After start up performance improved very fast:
- ☑ peak luminosity 2×10^{32} in 2010 and 3.6×10^{33} cm^{-2} sec^{-1} in 2011
- ☑ 2012 data taking @ $\sqrt{s}$=8 TeV, peak luminosity ~7.7×10^{33} cm^{-2} sec^{-1}





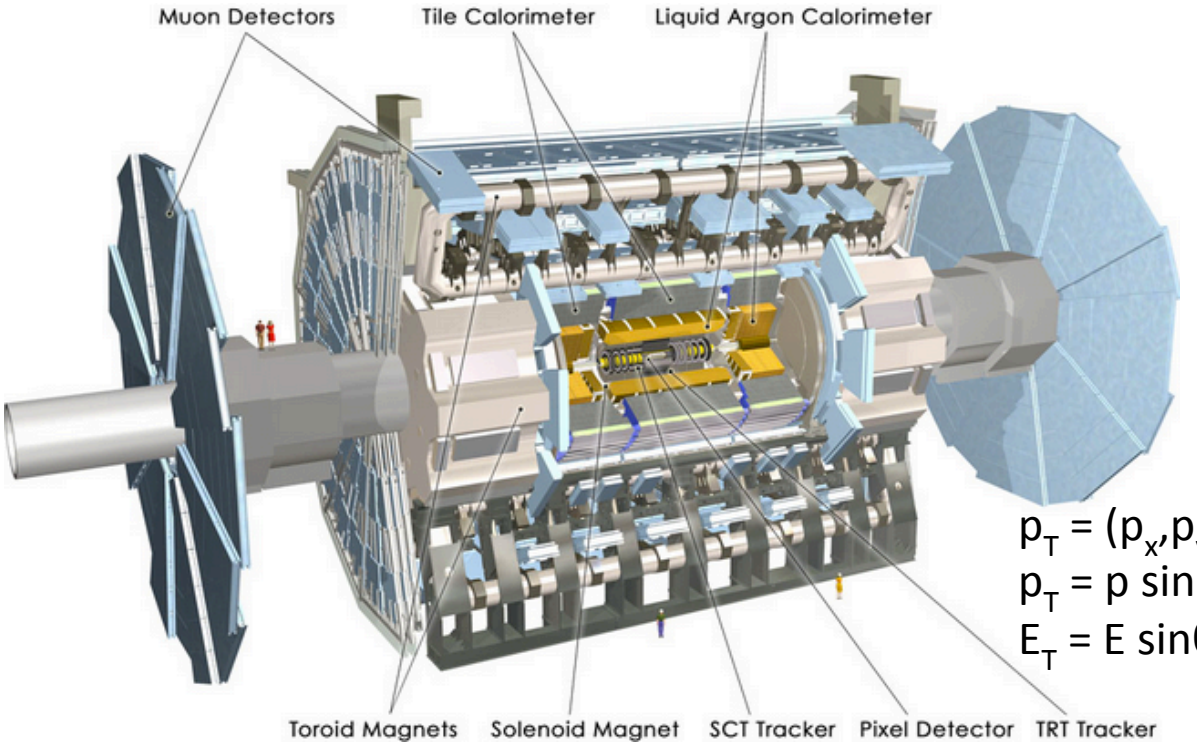
☑ATLAS experiment:

- ✓176 Institutions and 38 Countries,
- ✓**3200** physicists (incl. 1000 Students)

$$\mathcal{L} \propto \frac{N_1 N_2 n_b}{\sigma^2}$$

parameters:
N_i = bunch intensity
n_b = number of bunches
σ = colliding beam size

The ATLAS Detector



$p_T = (p_x, p_y)$
$p_T = p \sin\theta$
$E_T = E \sin\theta$

$\eta = -\ln \tan(\theta/2)$: pseudo rapidity

- Inner tracker
  $$\frac{\sigma(p_T)}{p_T} \approx 0.05\% \; p_T \oplus 1\%$$
- Calorimetry
  $$\text{EM}: \frac{\sigma(E)}{E} \approx \frac{10\%}{\sqrt{E}} \oplus 0.7\%$$
  $$\text{Had}: \frac{\sigma(E)}{E} \approx \frac{50\%}{\sqrt{E}} \oplus 3\%$$
- Muon spectrometer
  $$\frac{\sigma(p_T)}{p_T} \approx 2\% \quad @50 \text{ GeV}:$$
  $$\frac{\sigma(p_T)}{p_T} \approx 10\% \quad @\ 1 \text{ TeV}$$
- Magnets
  - ✓ solenoid : 2 T
  - ✓ toroid : 0.5 T (barrel), 1 T (endcap)
- Trigger
  - ✓ 3 Levels, 40 MHz → 200 Hz

General purpose, high resolution and hermetic detector

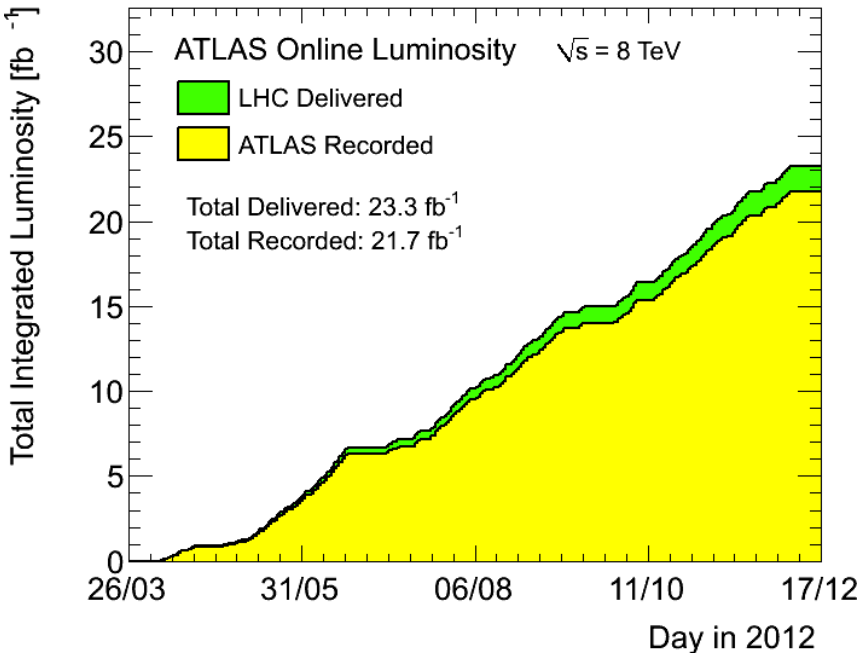
Inner Detector: $|\eta| < 2.5$, precise tracking and vertexing, particle ID, e/π separation

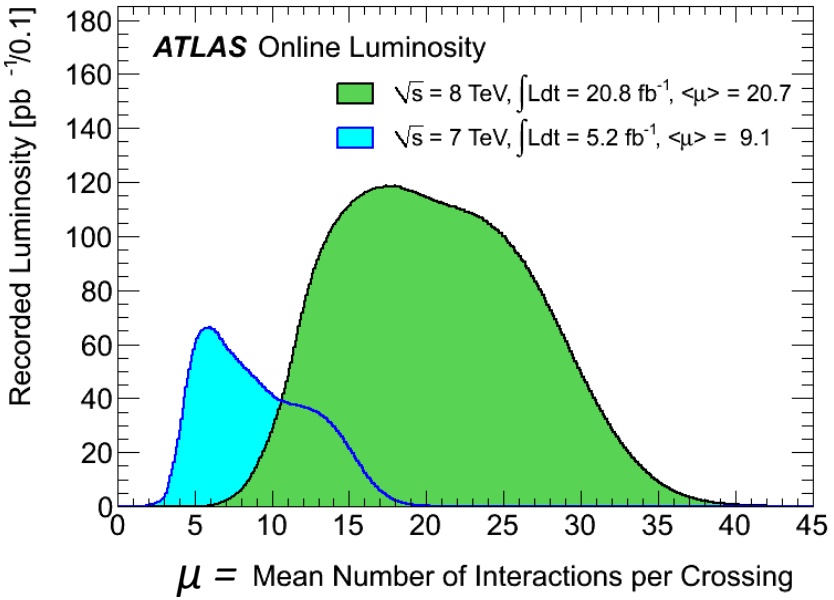
EM calo : $|\eta| < 3.2$, e/γ trigger, Id, energy and position measurement

Hadronic Calo: $|\eta| < 4.9$, Tiles (Fe) + End Cap/Forward (Cu-W/Larg) calo: jets, E_T

Muon Spectrometer

pp Data Collected at 7 & 8 TeV

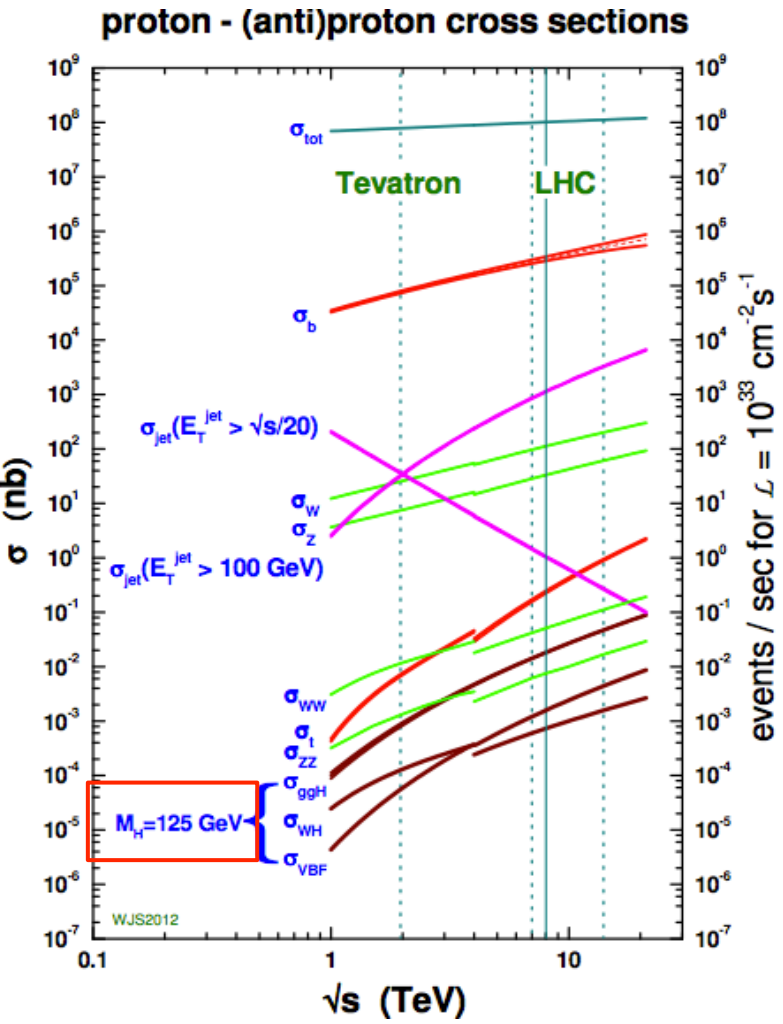




- ☑ High fraction of total delivered data was recorded
- ☑ ATLAS reconstruction algorithms perform consistently well, with corrections in some cases, for these level of pileup interactions
- ☑ Precision measurements are wrapping up on 7 TeV data and updating on 8 TeV
- ☑ Several new searches and present searches updated results with 8 TeV data and more updates are well underway…….

ATLAS Physics Results

W.J. S1rling, private communica1on



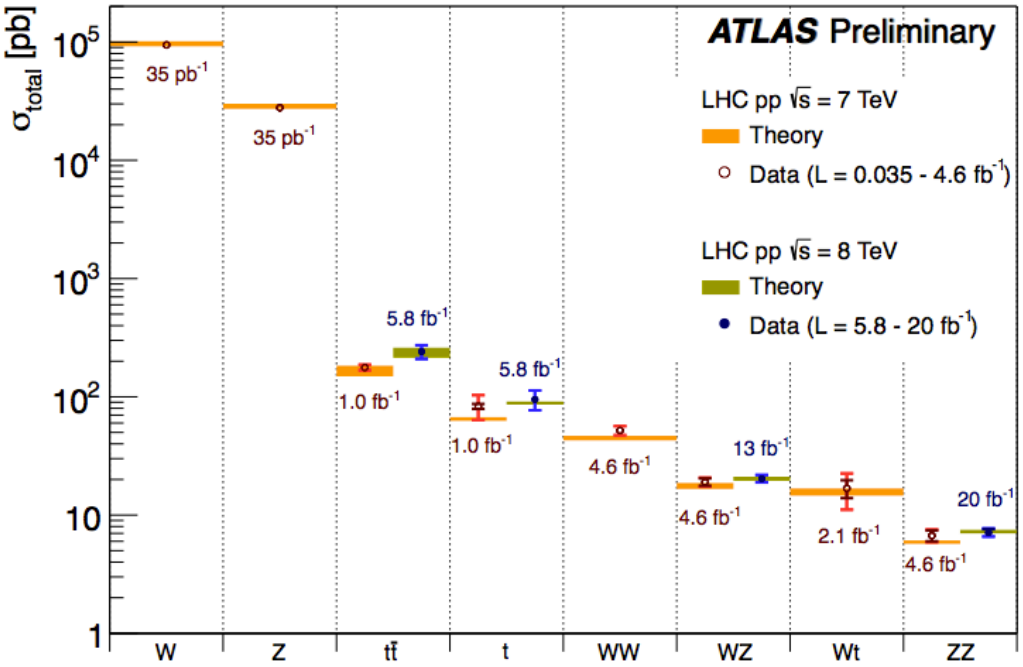
Compare strong interaction rates with electroweak Interaction rates

– e.g. top vs. W,Z,H

Keep an eye out for (new) physics processes whose cross sections increase dramatically as LHC moves to design energy

Physics Publications	
Bottom, Charm	8
Top	29
Standard Model	67
Higgs	25
Exotics	66
SUSY	51
Heavy Ion	9
Sum	255

Standard Model Cross sections



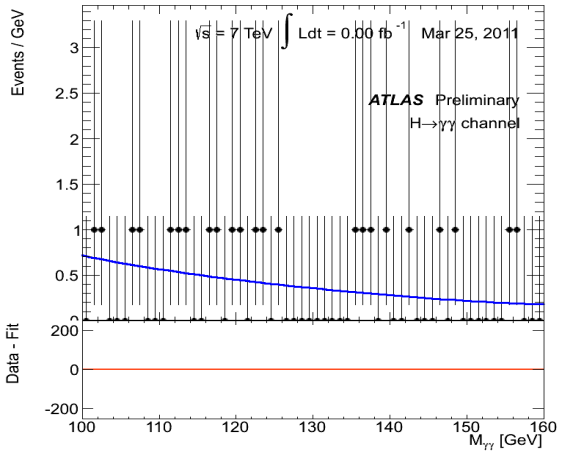
- ☑ Standard Model continues to be validated
- ☑ Besides finding the missing piece, the Higgs !
- ☑ Found impressive agreement with theory across orders of magnitude
  - ☑ Continuing to explore ever smaller cross section
- ☑ Established a stable ground for new physics searches
  - ☑ Still, deeper understanding is needed (PDF, NNLO QCD calculations, NLO EWK corr.)

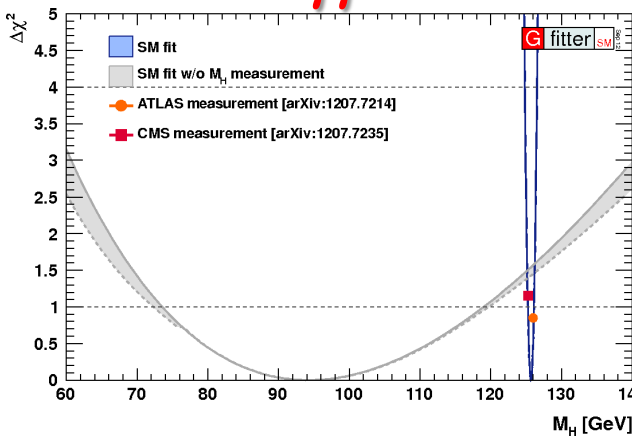
More Details: Following talks

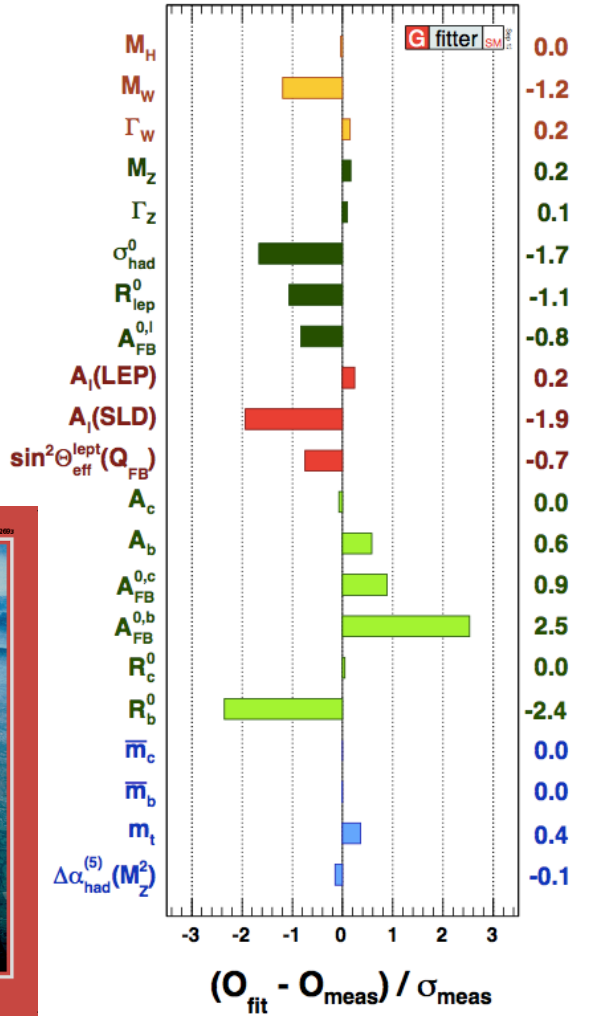
- ☑ Luke Lambourne: "Standard Model Physics with ATLAS"
- ☑ Joseph David Price : "Higgs Physics with ATLAS"
- ☑ Higgs Overview : see Richard Dante St. Denis on Aug. 22
- ☑ "Overview of the ATLAS Higgs Results"
- ☑ Thomas James Neep: "Top Physics at ATLAS"
- ☑ Mathias Hamer: "SUSY Searches with ATLAS"
- ☑ Andrii Tykhonov: "Exotics Searches with ATLAS"
- ☑ Ina Chalupkova: "Heavy Flavor Physics with ATLAS"
- ☑ Only a selection of recent ATLAS results is presented
- ☑ All ATLAS public results on
- ☑ http://twiki.cern.ch/twiki/bin/view/AtlasPublic/

Higgs: Where do we stand?

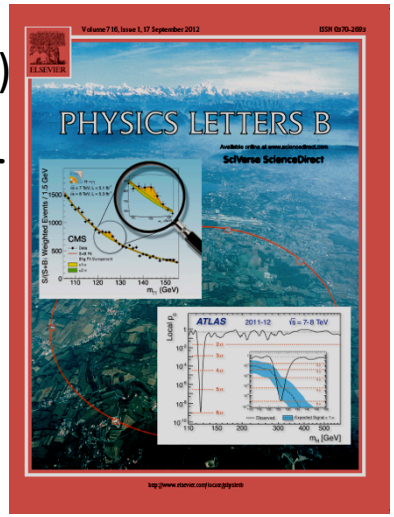
$H \rightarrow \gamma\gamma$







$m_H = 125.5 \pm 0.2\ (stat) \pm 0.6\ (sys)$ GeV (ATLAS)



Last year's discovery is probably the most important event in High Energy Physics in the last 30 years.
Will it be the triumph of the Standard Model or a gateway to new physics?

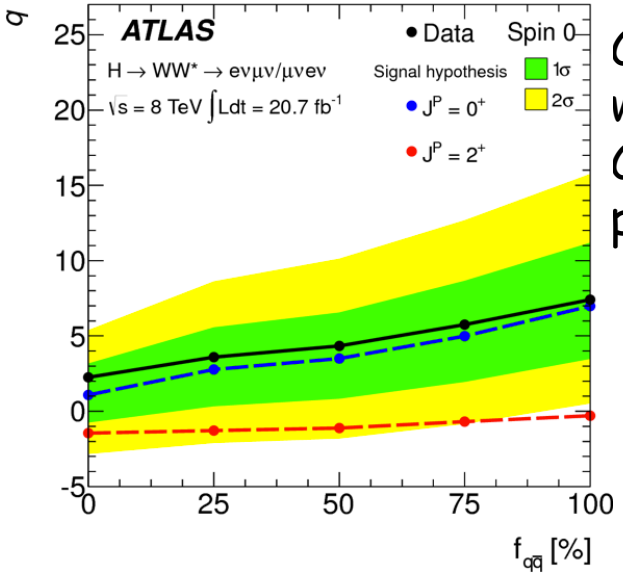
Consistency of the Standard Model:
By comparing fit results with direct measurement - no pull value exceeds deviations of more than 3 sigma.

Experimental precision of m_H already excellent for electroweak parameter fitting

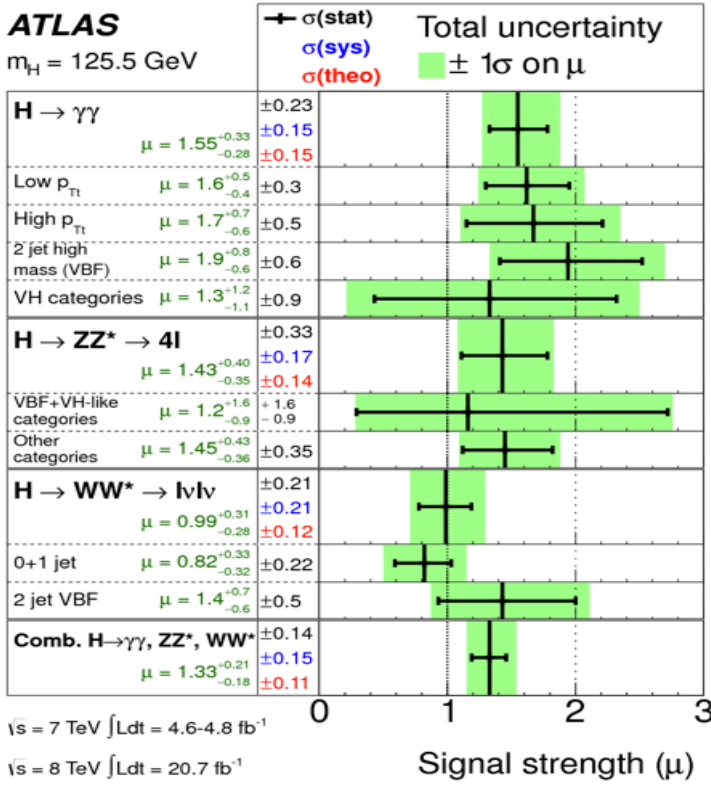
Higgs Property measurements

ATLAS-CONF-2013-029 ; ATLAS-CONF-2013-031

	ATLAS
Mass	125.5 ± 0.2(stat) ± 0.6(syst)
Data favors 0+ vs	
0-	97.8% CL (excluded)
1	99.7% CL (excluded)
2+	99.9% CL (excluded)



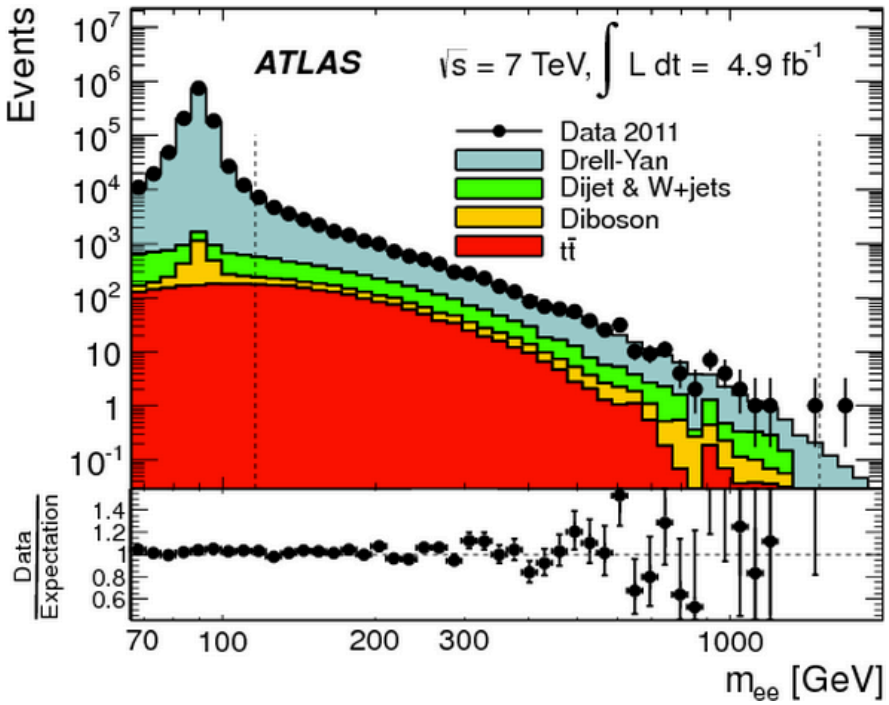
Compatibility of the data with each spin hypothesis Computed using a CL_S procedure.



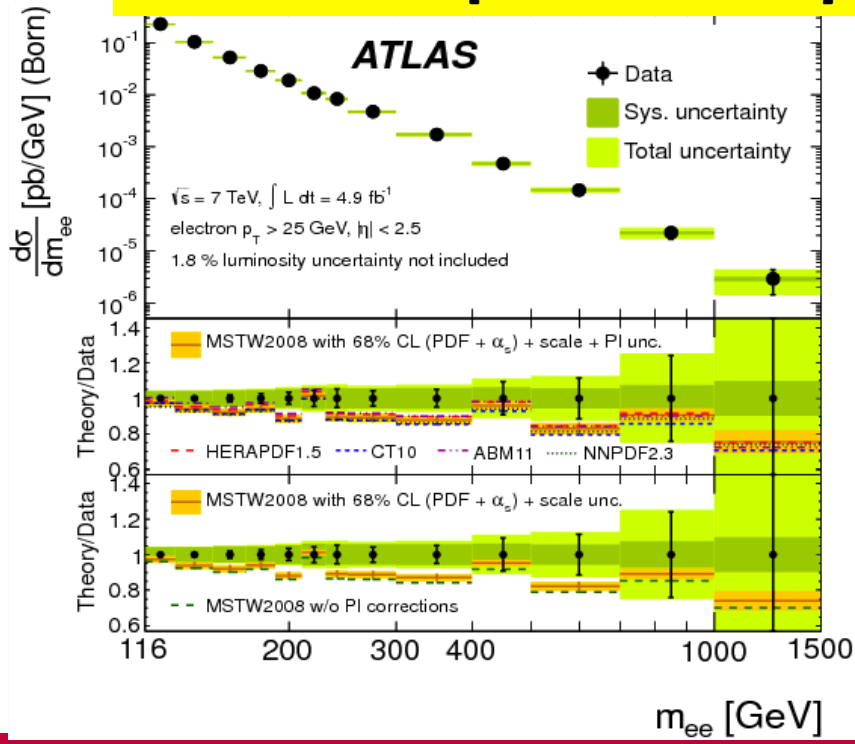
- ☑ **Couplings to gauge bosons determined at the 10% level**
- ☑ **Rejecting zero couplings to fermions at >5σ level**
- ☑ Observation of
  - ☑ **VBF production is at 3.3σ**

SM: Drell-Yan Cross section

- ☑ High mass differential cross section in $Z/\gamma^* \rightarrow e^+e^-$ as a function of invariant mass (M_{ee}) and corrected for detector effects
- ☑ Dijet and W+jets background calculated with data derived fake rates
- ☑ Comparison with event generators show a good agreement
  - ☑ No sign of new physics required for this level of agreement

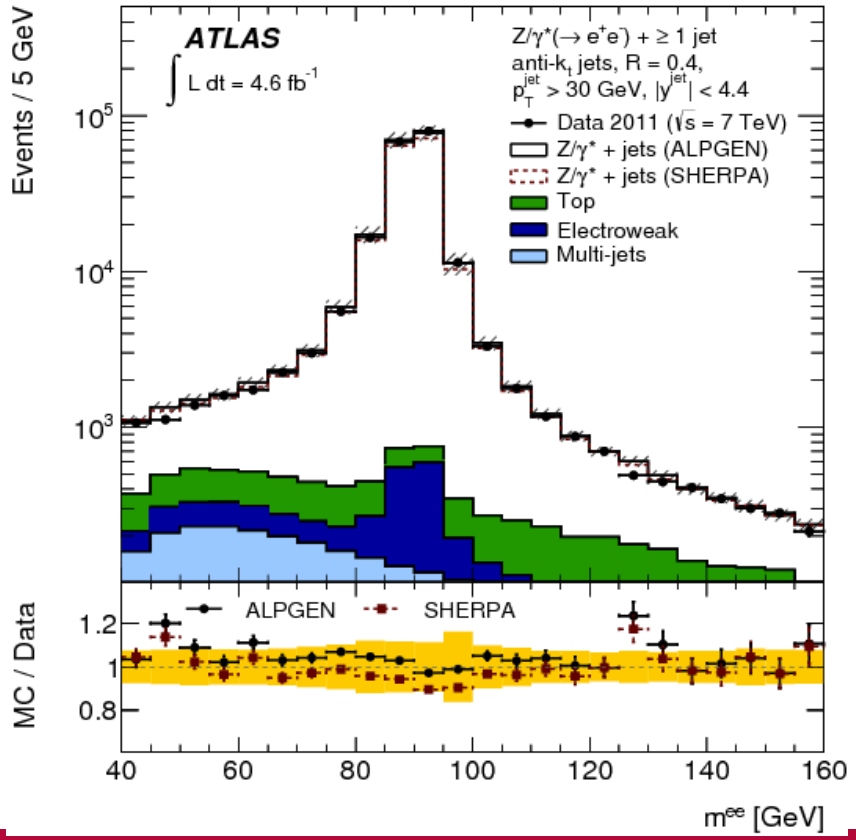


arXiv:1305.4192 [submitted to PLB]

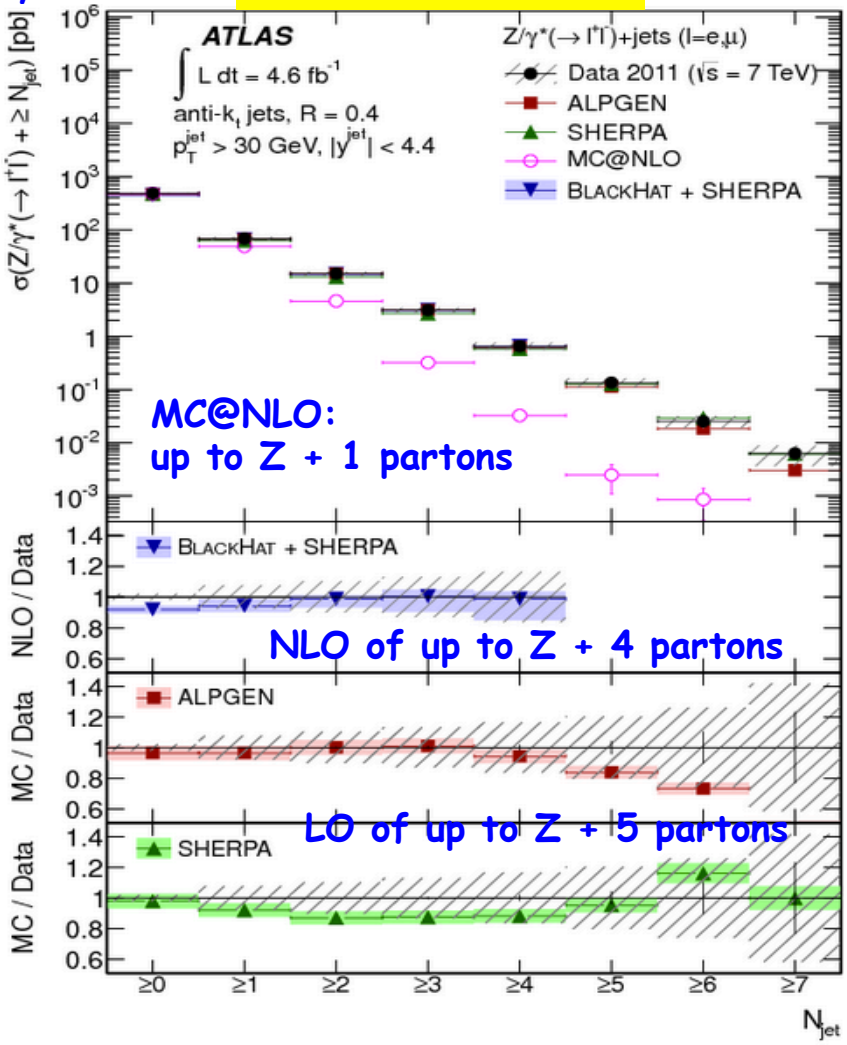


SM: Z + jet production

- ☑ Inclusive and differential cross section in Z + jet
- ☑ Test new NLO predictions of jet multiplicity and momentum
- ☑ Confirms Poisson scaling for exclusive jet multiplicity bins in high p_T regime



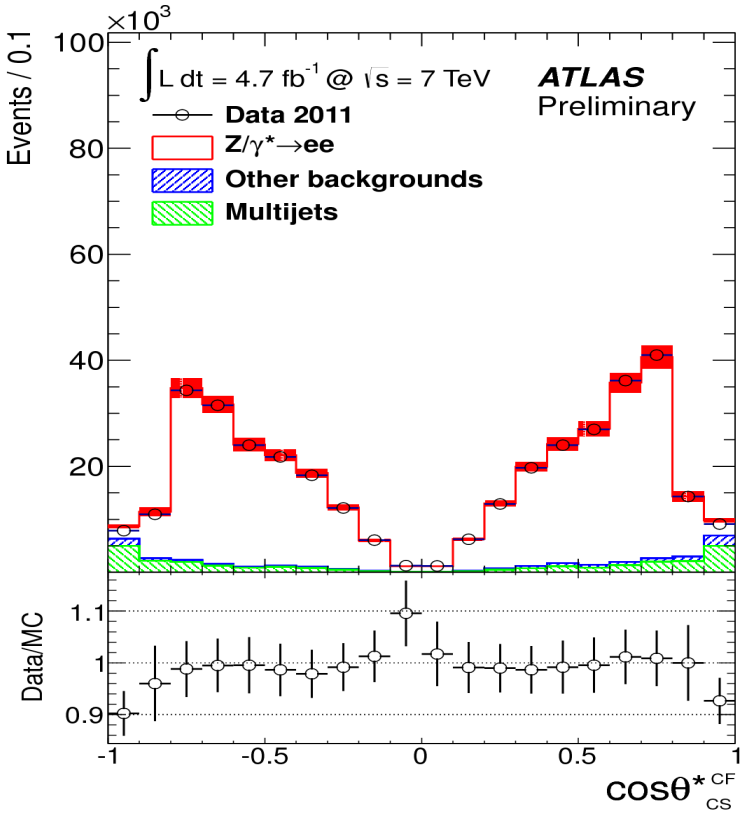
JHEP 07(2013) 032

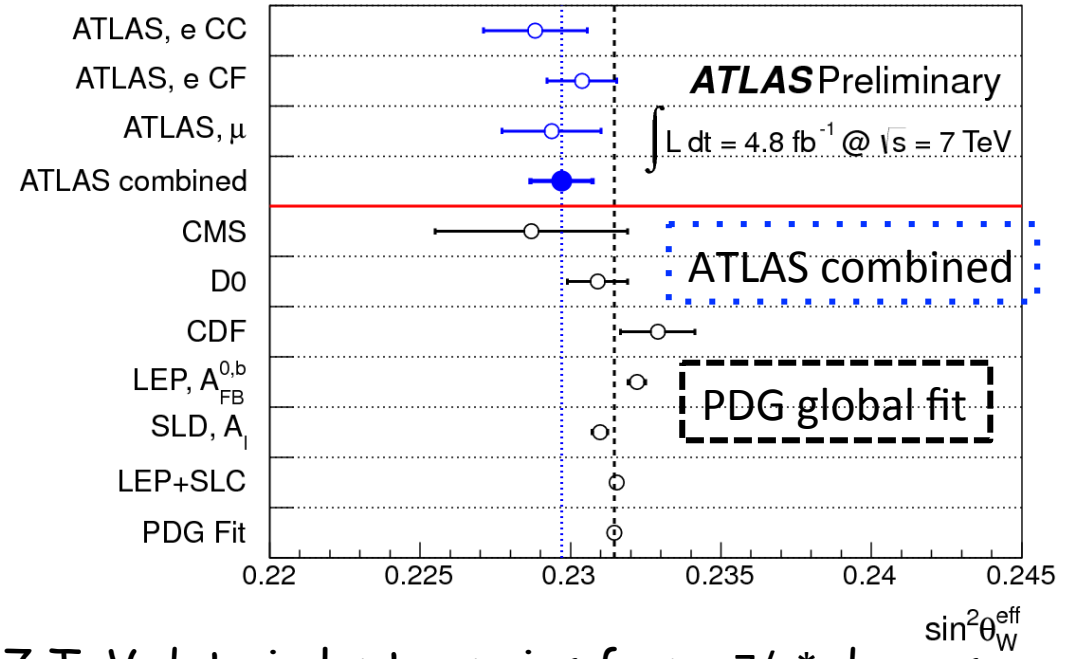


Forward/backward asymmetry Z/γ*

A_{FB} in Z-boson rest-frame is measured and used to determine the effective weak mixing angle $\sin^2\theta^{eff}_W$

ATLAS-CONF-2013-043





7 TeV data in lepton pairs from Z/γ* decays

$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$

$$\sin^2\theta^{eff}_W = 0.2297 \pm 0.0004(\text{stat}) \pm 0.0009(\text{sys})$$

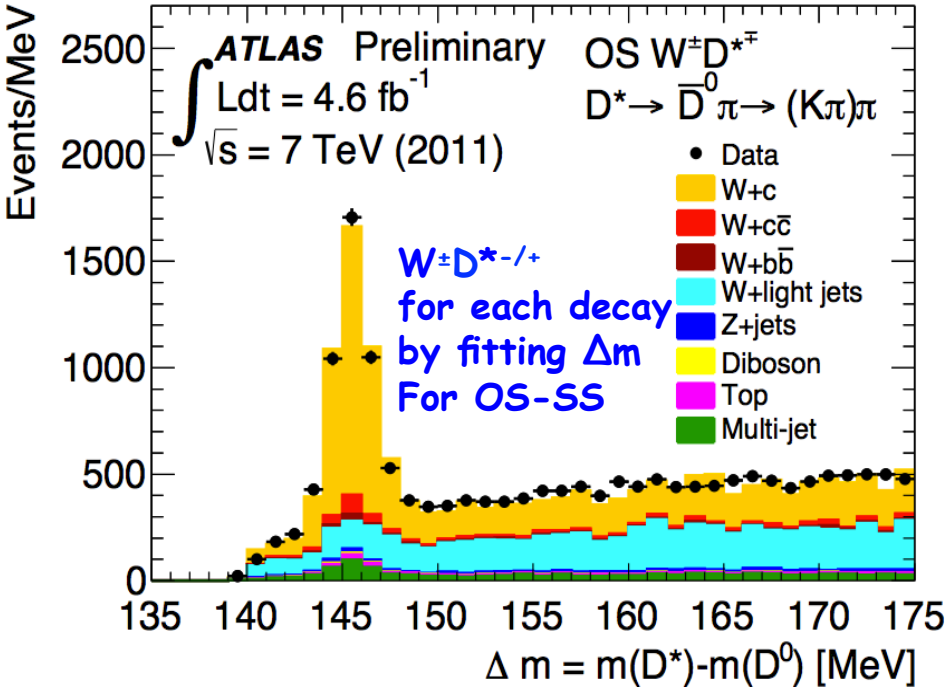
consistent with previous measurements, and as precise as the D-Zero result

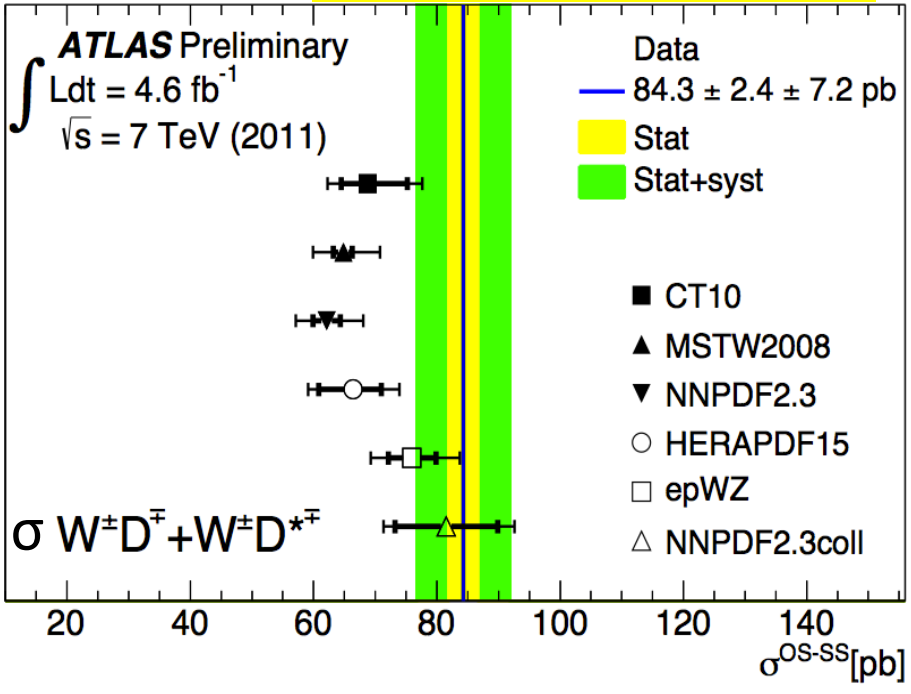
A_{FB} spectra were found to be consistent with the corresponding Standard Model predictions.

W + charm production

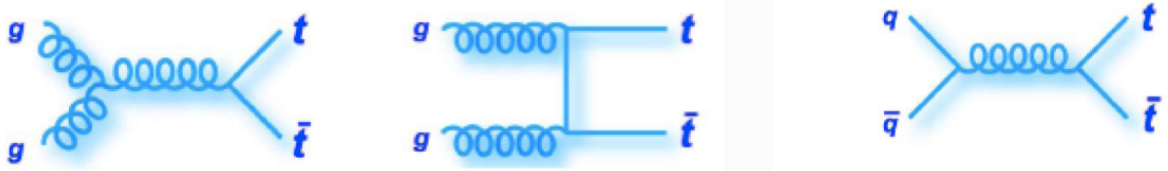
- ☑ measurement of the cross section for the production of a single charm hadron in association with a W boson: $W \rightarrow \ell\nu$, $(D^{*+} \rightarrow D^0(K^-\pi^+)\,\pi^+)$
- ☑ Directly sensitive to s-quark parton distribution function
  - ☑ Comparison of different PDF parameterization
- ☑ Use exclusive reconstruction to identify charm hadrons in the event
  - ☑ Single charm hadron yield extracted using charge correlation with $W^{\pm}$

ATLAS-CONF-2013-045



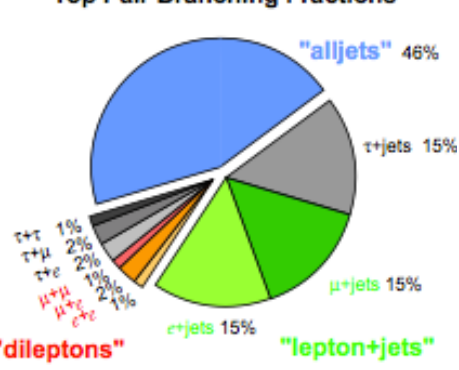


Top quark physics at the LHC

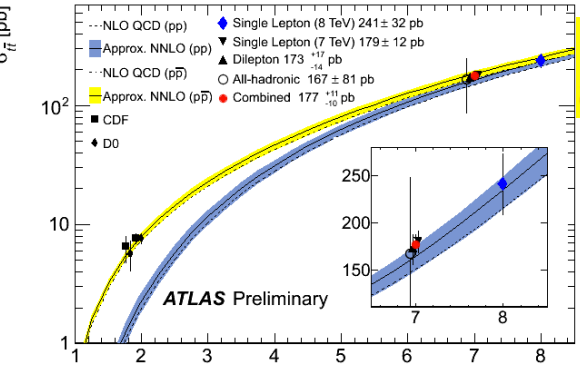


☑ Heaviest particle in the SM: special role in EW symmetry breaking? Large coupling to Higgs boson

final states, Top decays through t→Wb



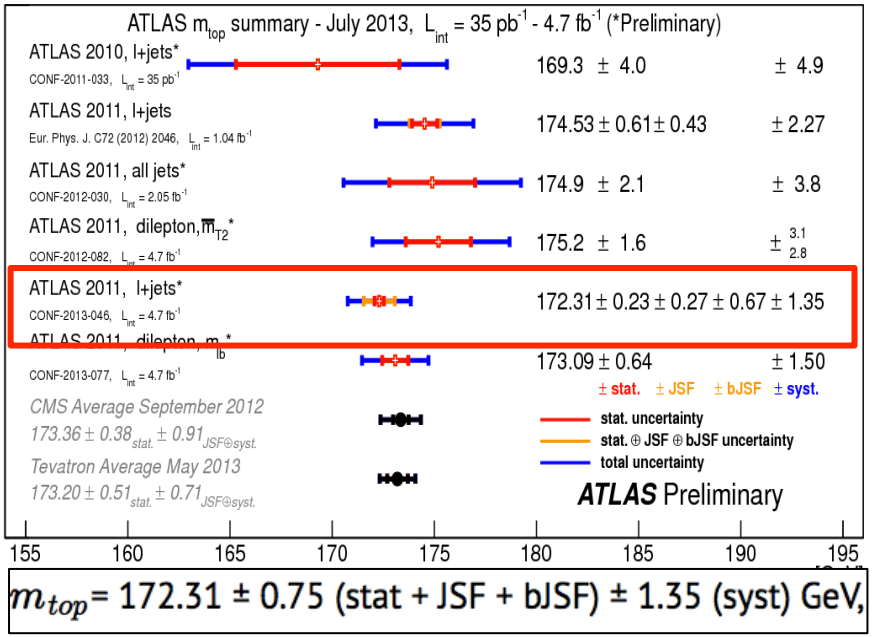
Tool for precise tests of SM and an interesting hunting place for new physics !



7 TeV: σ = 177+11-10 pb
8 TeV: σ = 241±32 pb

Top studies are a testing ground for NLO and NNLO calculations for QCD

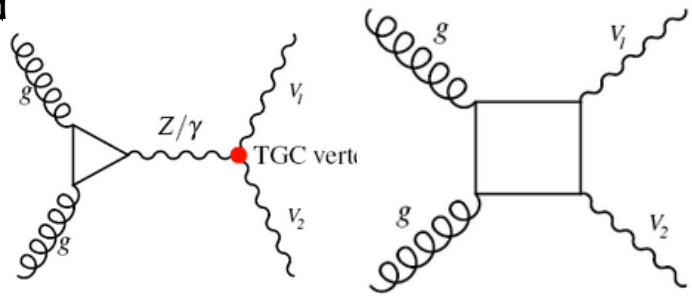
ATLAS-CONF-2013-046



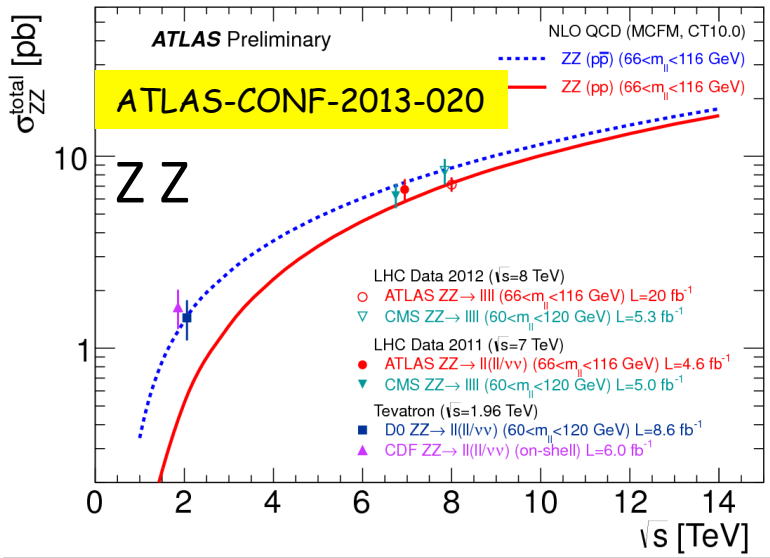
New result using a 3D template technique which determines m_{top} together with a global jet E scale factor (JSF) and a relative b-jet to light jet scale factor (bJSF). First implementation of simultaneous 3D fit. Systematics reduced by 40% - relative to previous measurement

Diboson physics

- ☑ Importance of di-boson production: significant and irreducible background for Higgs and exotica searches: for m_H = 125 GeV, H→VV is 25%
- ☑ Sensitive to Triple Gauge Couplings. Deviations could indicate physics beyond SM, as neutral TGC.

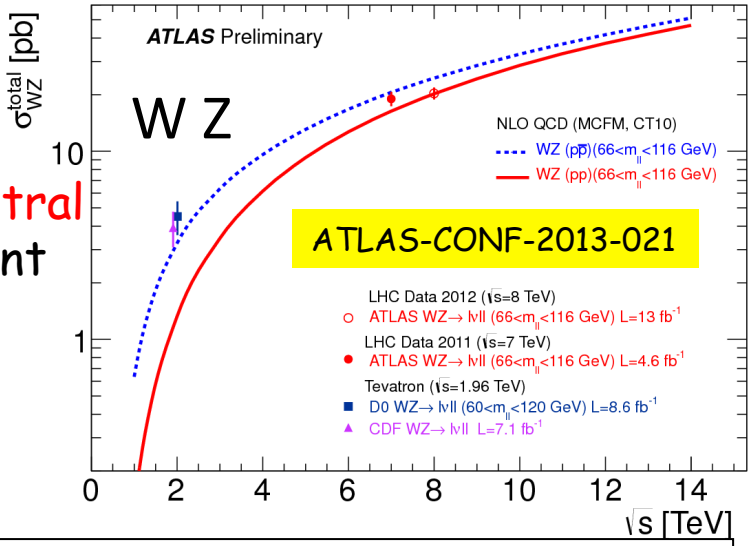


  - For WWZ and WWγ, limits compatible or tighter than Tevatron
  - For anomalous TGC, limits tighter then LEP and Tevatron.



$$\sigma(pp \to ZZ) = 7.1^{+0.5}_{-0.4}(stat) \pm 0.3(sys) \pm 0.2(lum)\ pb$$

Charged and neutral TGC: in agreement with the SM.



$$\sigma(pp \to WZ) = 20.3^{+0.8}_{-0.7}(stat)^{+1.2}_{-1.1}(sys)^{+0.7}_{-0.6}(lum)\ pb$$

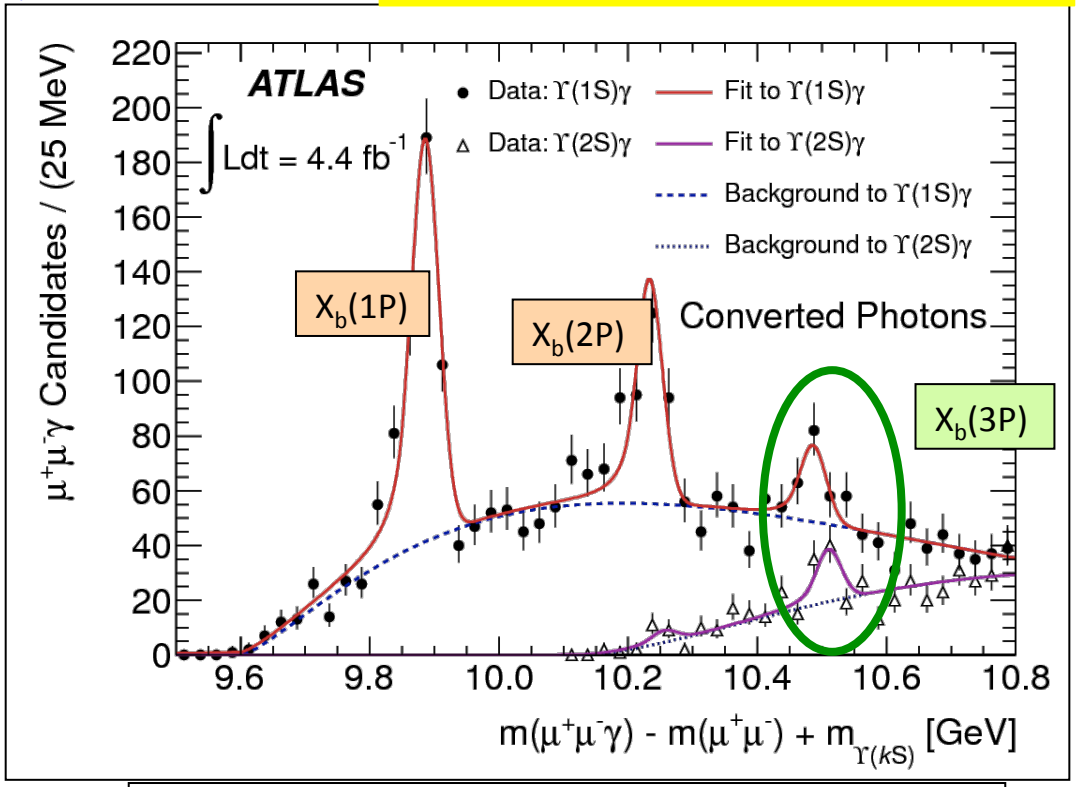
Good agreement with NLO MCFM

H. F. Physics: $\chi_b(3P)$ – 7 TeV
First discovery of a new particle

- ☑ Investigating μ+ μ- γ final states, dimuons from Υ(1S) Υ(2S)
- ☑ $\chi_b(1P)$ m = 9.9 GeV and $\chi_b(2P)$ m = 10.2 GeV states clearly visible
- ☑ New structure at 10.5 GeV observed by ATLAS --> χ_b (3P) with converted and unconverted photons
- ☑ Mass and decay properties consistent with $\chi_b(3P)$ expectations

confirmed by D^0 and LHCb with no improvement compared to ATLAS (due to lack of stat and mass resolution)

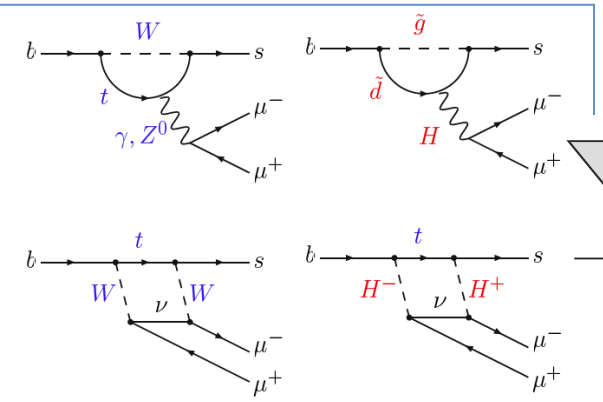
Phys. Rev. Lett. 108, 152001 (2012)

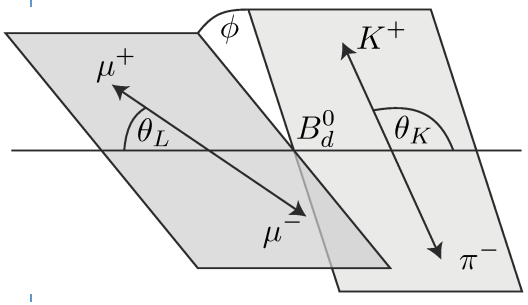


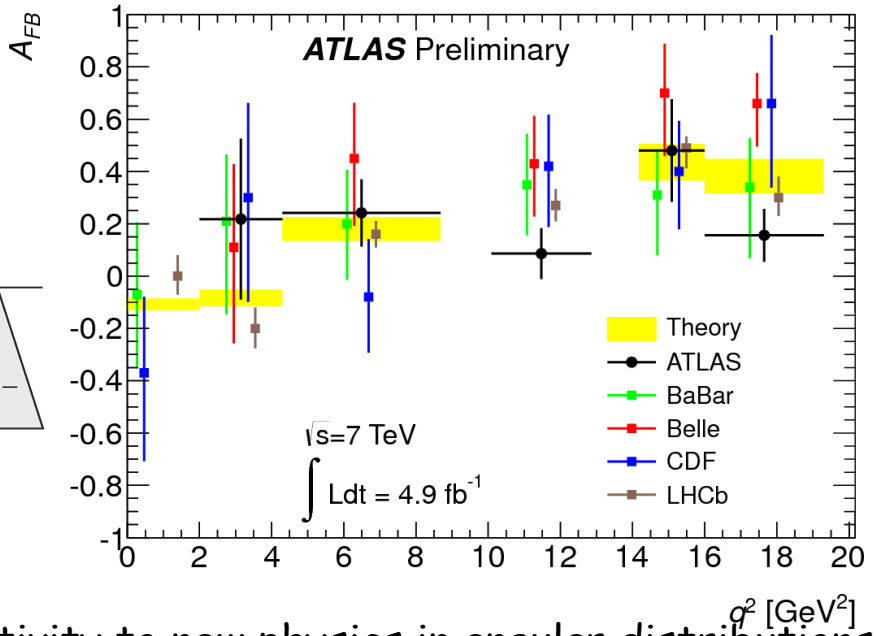
M = 10.530 ± 0.005(stat) ± 0.009(syst) GeV

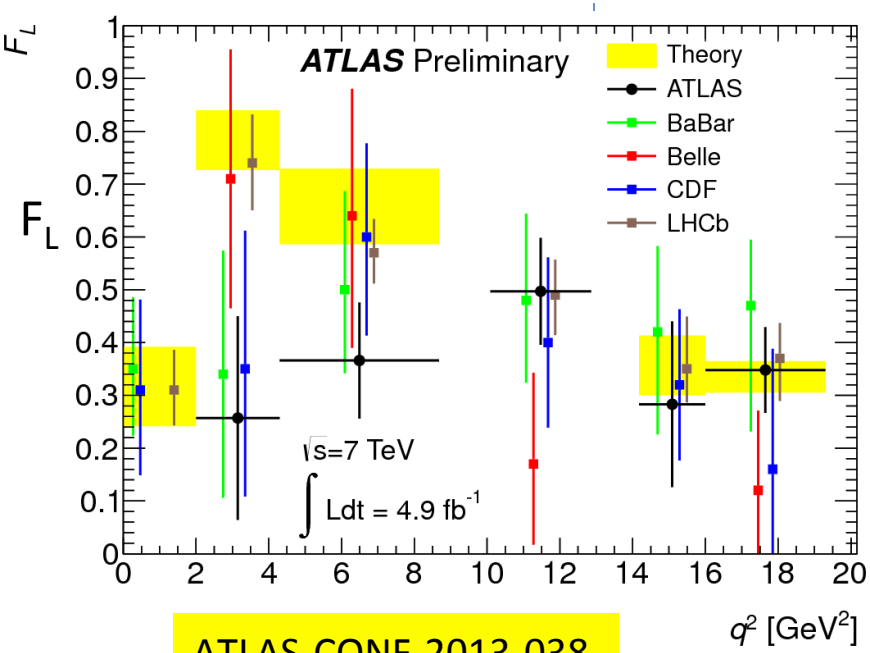
Heavy Flavour Physics: $B^0_d \to K^{0*} \mu \mu$

Angular analysis semi-rare decays of $B^0_d \to K^{0*} \mu \mu$. Penguin and box diagrams in SM









ATLAS-CONF-2013-038

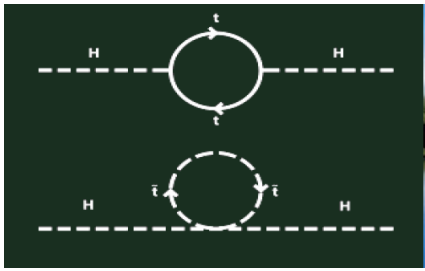
- ☑ Sensitivity to new physics in angular distributions and decay amplitudes.

F_L: K^{0*} longitudinal polarisation factor

A_{FB}: lepton forward-backward asymmetry

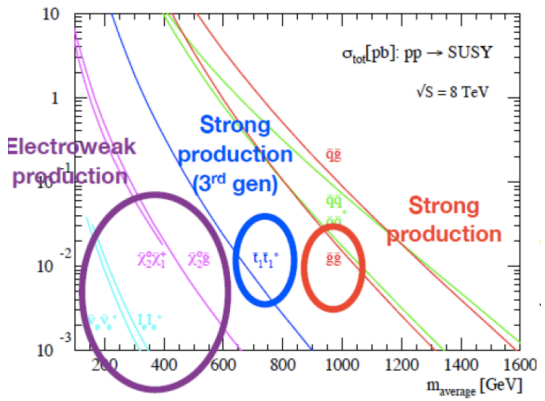
- ☑ Observables: binning over q^2(inv. mass^2 μμ)
- ☑ Results mostly consistent with theory, except at low F_L
- ☑ On going: CP-violation in B_s and P-violation in Λ_b

SUSY Searches



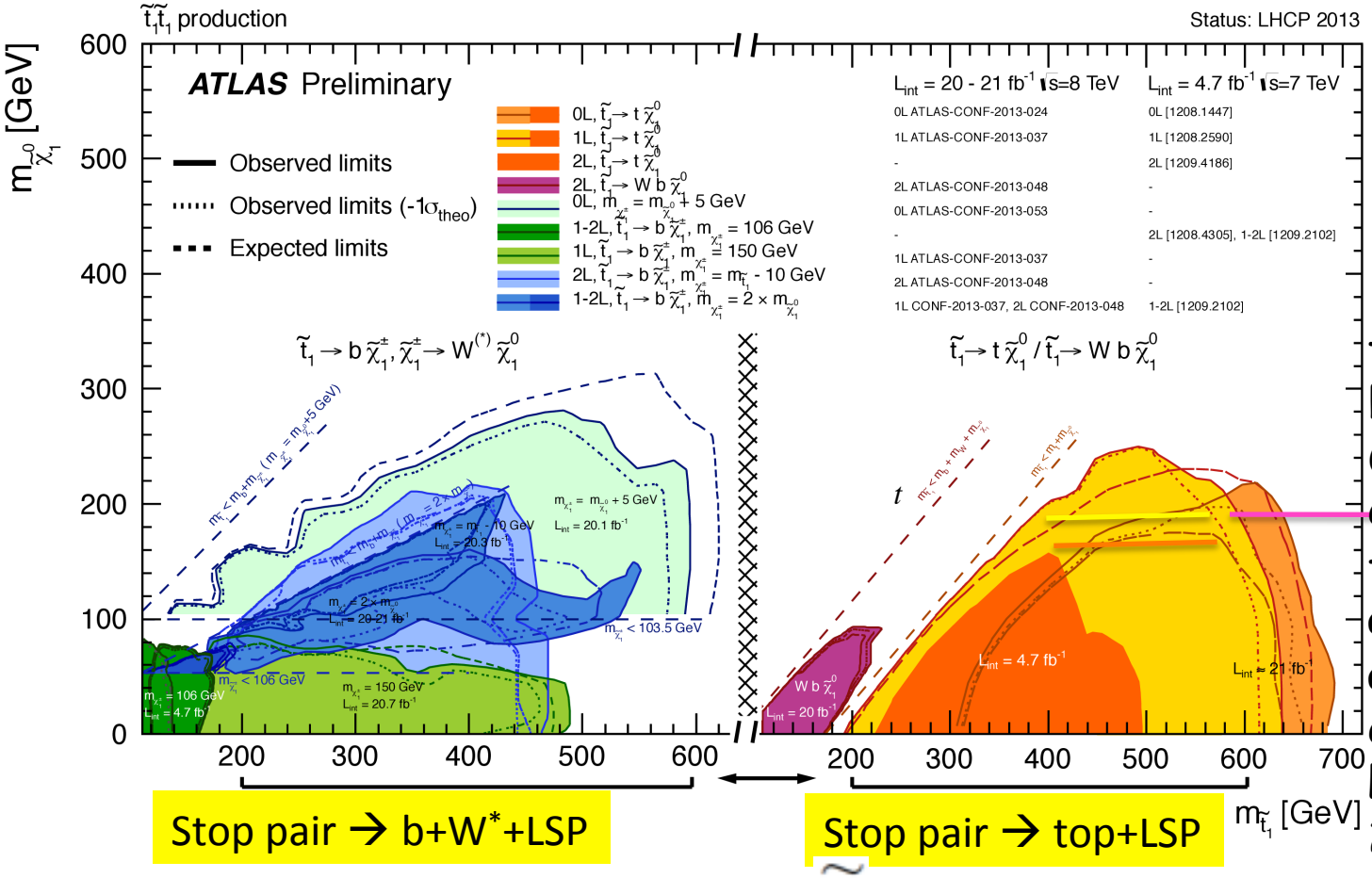
- ☑ SUSY is attractive for several reasons:
  - Stabilizes the Higgs boson mass and as bonus
  - Provides a dark matter candidate m~O(100) GeV
  - Allows unification of gauge couplings at high E
- ☑ Difficult to keep MSSM "natural" with a m_H = 125 GeV, as this m_H would require very heavy stops. Large parts of MSSM parameter space are excluded.

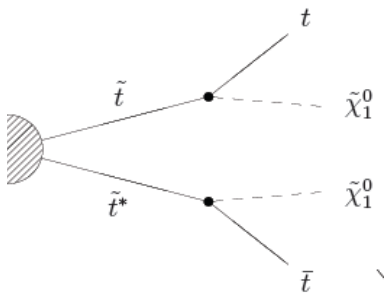
  MSSM: explore a space with ~ 100 free parameters.
- ☑ But EW scale SUSY is still possible with
  - large mixing in the stop sector (1 light stop and 1 heavy or both below ~1 TeV)
  - Extra matter gauge fields : extra gauge Boson, more complicated Higgs sector



Natural SUSY scenario:
- lightest chargino, neutralino and stop ~500GeV
- squark and gluino above 1 TeV.
- stop as to be light (<1TeV) to cancel large top contributions to Higgs mass

Direct Stop searches





top squark masses between 200 and 610GeV are excluded at 95%CL for massless LSP, and top squark around 500 GeV are excluded for LSP masses up to 250 GeV.

Stop pair → b+W*+LSP

Stop pair → top+LSP

Exclusion limits at 95% CL are shown in $\tilde{t}$ - $\tilde{\chi}_1$ mass plane

Note that these plots overlay contours belonging to different stop decay channels, different sparticle mass hierarchies, and simplified decay scenarios. Interpretation should be done with care.

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: LHCP 2013

No sign of new physics

ATLAS Preliminary

$\int Ldt$ = (4.4 - 20.7) fb^{-1} $\sqrt{s}$ = 7, 8 TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int Ldt$ [fb^{-1}]	Mass limit		Reference
Inclusive searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$	1.8 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	4 jets	Yes	5.8	$\tilde{q}, \tilde{g}$	1.24 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2012-104
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-054
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$	740 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$ = 0 GeV	ATLAS-CONF-2013-047
	Gluino med. $\tilde{\chi}^\pm$ ($\tilde{g}\to q\bar{q}\tilde{\chi}^\pm$)	1 e, μ	3-6 jets	Yes	4.7	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)$ < 200 GeV, $m(\tilde{\chi}^\pm)$ = 0.5($m(\tilde{\chi}_1^0)$+$m(\tilde{g})$)	1208.4688
	$\tilde{g}\tilde{g}\to qqqqll(ll)\tilde{\chi}_1^0\tilde{\chi}_1^0$	2 e, μ (SS)	3 jets	Yes	20.7	$\tilde{g}$	1.1 TeV	$m(\tilde{\chi}_1^0)$ < 650 GeV	ATLAS-CONF-2013-007
	GMSB (ℓ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	tanβ < 15	1208.4688
	GMSB (l NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$	1.4 TeV	tanβ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	0	Yes	4.8	$\tilde{g}$	1.07 TeV	$m(\tilde{\chi}_1^0)$ > 50 GeV	1209.0753
	GGM (wino NLSP)	1 e, μ + γ	0	Yes	4.8	$\tilde{g}$	619 GeV	$m(\tilde{\chi}_1^0)$ > 50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)$ > 220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	m(H) > 200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	$m(\tilde{G})$ > 10^{-4} eV	ATLAS-CONF-2012-147
3^d gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	12.8	$\tilde{g}$	1.24 TeV	$m(\tilde{\chi}_1^0)$ < 200 GeV	ATLAS-CONF-2012-145
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	2 e, μ (SS)	0-3 b	No	20.7	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)$ < 500 GeV	ATLAS-CONF-2013-007
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.14 TeV	$m(\tilde{\chi}_1^0)$ <200 GeV	ATLAS-CONF-2013-054
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	3 b	Yes	12.8	$\tilde{g}$	1.15 TeV	$m(\tilde{\chi}_1^0)$ < 200 GeV	ATLAS-CONF-2012-145
3^d gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-630 GeV	$m(\tilde{\chi}_1^0)$ < 100 GeV	ATLAS-CONF-2013-053
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$	430 GeV	$m(\tilde{\chi}_1^\pm)$ = 2 $m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$ (light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$	167 GeV	$m(\tilde{\chi}_1^0)$ = 55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$ (light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	220 GeV	$m(\tilde{\chi}_1^0)$ = $m(\tilde{t}_1)$ - m(W) - 50 GeV, $m(\tilde{t}_1)$ << $m(\tilde{\chi}_1^\pm)$	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$ (medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	150-440 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV, $m(\tilde{t}_1)$-$m(\tilde{\chi}_1^\pm)$ = 10 GeV	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$ (medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1 e, μ	4 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$ < 200 GeV, $m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^0)$ = 5 GeV	ATLAS-CONF-2013-053
	$\tilde{t}_1\tilde{t}_1$ (heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e, μ	0	Yes	20.7	$\tilde{t}_1$	200-610 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$ (heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$	320-660 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$	500 GeV	$m(\tilde{\chi}_1^0)$ > 150 GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$	520 GeV	$m(\tilde{t}_1)$ = $m(\tilde{\chi}_1^0)$ + 180 GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{l}_{L,R}\tilde{l}_{L,R}, \tilde{l}\to l\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{l}$	85-315 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp, \tilde{\chi}_1^\pm\to l\nu\,(l\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	125-450 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV, $m(\tilde{l},\tilde{\nu})$ = 0.5($m(\tilde{\chi}_1^\pm)$ + $m(\tilde{\chi}_1^0)$)	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp\to\tilde{\tau}\nu\,(\tau\tilde{\nu})$	2 τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$	180-330 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV, $m(\tilde{\tau},\tilde{\nu})$ = 0.5($m(\tilde{\chi}_1^\pm)$ + $m(\tilde{\chi}_1^0)$)	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to l_L\nu l_L l(\tilde{\nu}\nu)$, $l\tilde{\nu} l_L l(\tilde{\nu}\nu)$	e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	600 GeV	$m(\tilde{\chi}_1^\pm)$ = $m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$ = 0, $m(\tilde{l},\tilde{\nu})$ = 0.5($m(\tilde{\chi}_1^\pm)$ + $m(\tilde{\chi}_1^0)$)	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W^{(*)}\tilde{\chi}_1^0 Z^{(*)}\tilde{\chi}_1^0$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	315 GeV	$m(\tilde{\chi}_1^\pm)$ = $m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$ = 0, sleptons decoupled	ATLAS-CONF-2013-035
Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp$ prod., long-lived $\tilde{\chi}_1^\pm$	0	1 jet	Yes	4.7	$\tilde{\chi}_1^\pm$	220 GeV	1 < $\tau(\tilde{\chi}_1^\pm)$ < 10 ns	1210.2852
	Stable g, R-hadrons	0-2 e, μ	0	Yes	4.7	$\tilde{g}$	985 GeV		1211.1597
	GMSB, stable $\tilde{\tau}$, low β	2 e, μ	0	Yes	4.7	$\tilde{\tau}$	300 GeV	5 < tanβ < 20	1211.1597
	GMSB, $\tilde{\chi}_1^0\to\gamma$G,long-lived $\tilde{\chi}_1^0$	2 γ	0	Yes	4.7	$\tilde{\chi}_1^0$	230 GeV	0.4 < $\tau(\tilde{\chi}_1^0)$ < 2 ns	1304.6310
	$\tilde{\chi}_1^0\to$ qqμ (RPV)	1 e, μ	0	Yes	4.4	$\tilde{q}$	700 GeV	1 mm < cτ < 1 m, $\tilde{g}$ decoupled	1210.7451
RPV	LFV pp→$\tilde{\nu}_\tau$+X, $\tilde{\nu}_\tau\to$e+μ	2 e, μ	0	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV pp→$\tilde{\nu}_\tau$+X, $\tilde{\nu}_\tau\to$e(μ)+τ	1 e,μ + τ	0	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e, μ	7 jets	Yes	4.7	$\tilde{q}, \tilde{g}$	1.2 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$ < 1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to$eeν_μ,e$\mu\nu$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm$	760 GeV	$m(\tilde{\chi}_1^0)$ > 300 GeV, λ_{121} > 0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to\tau\tau\nu_e$,e$\tau\nu_\tau$	3 e, μ + τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$	350 GeV	$m(\tilde{\chi}_1^0)$ > 80 GeV, λ_{133} > 0	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6 jets	-	4.6	$\tilde{g}$	666 GeV		1210.4813
	$\tilde{g}\to t\bar{t}, t_1\to bs$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$	880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	$m(\chi)$ < 80 GeV, limit of < 687 GeV for D8	ATLAS-CONF-2012-147

Inclusive

Gluinos

Stop-Squarks

1 TeV

Neutralino,chagino

Long Lived

R parity viol.

$\sqrt{s}$ = 7 TeV full data

$\sqrt{s}$ = 8 TeV partial data

$\sqrt{s}$ = 8 TeV full data

10^{-1} 1

Mass scale [TeV]

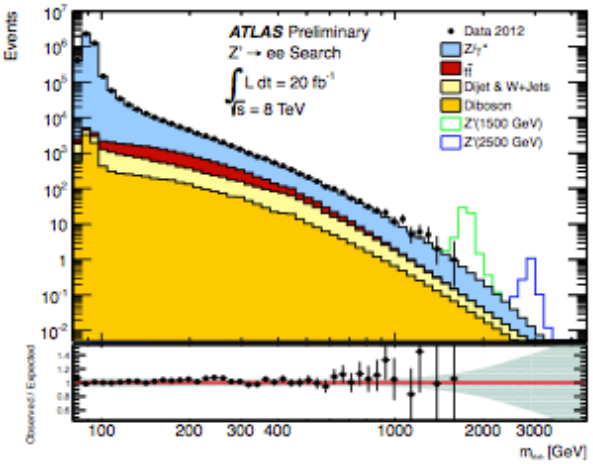
*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

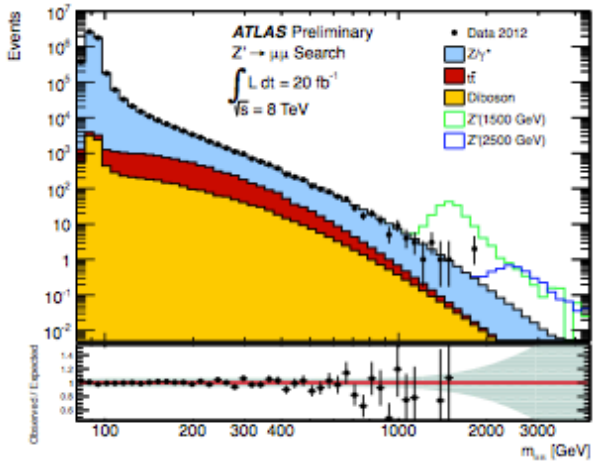
Exotics

- ☑ Many extensions of the SM other than SUSY have been developed
  - ✓ Extra dimensions, Technicolor(s), Little Higgs, no Higgs, GUT,
  - ✓ Lepto-quarks, Compositeness, Heavy and Vector like quarks, Heavy neutrino, TeV Gravity and Dark Matter
- ☑ Heavy Resonances:
  - ✓ Dilepton (see next slide)
  - ✓ Dibosons WZ and ZZ (next slide) ATLAS-CONF-2013-015 , ATLAS-CONF-2012-150
  - ✓ Dijet: excludes excited quarks $m(q^*) < 3.84$ TeV, ATLAS-CONF-2012-148
  - ✓ Top anti-top: Limits on leptophobic topcolor Z': 1.8 TeV, KK excitation of the gluon in Randall-Sundrum model: 2 TeV ATLAS-CONF-2013-052
  - ✓ W ' → t b , excludes $W'_L (W'_R)$ below 1.74 TeV (1.84 TeV) ATLAS-CONF-2013-050
- ☑ Monojets ATLAS-CONF-2012-147
- ☑ Heavy top like quarks: T '> 790(640) GeV for weak isospin doublet (singlet) scenarios ATLAS-CONF-2013-018
- ☑ Same sign dileptons and b jets: vector like B(T) quarks excluded or masse B(T) > 0.59 (0.54) TeV if B(T) are singlets; chiral b' quarks excluded below 0.72 TeV; inverse size of extra dimensions > 0.90 TeV ATLAS-CONF-2013-051
- ☑ Excited leptons / Type III Seesaw Model heavy fermions

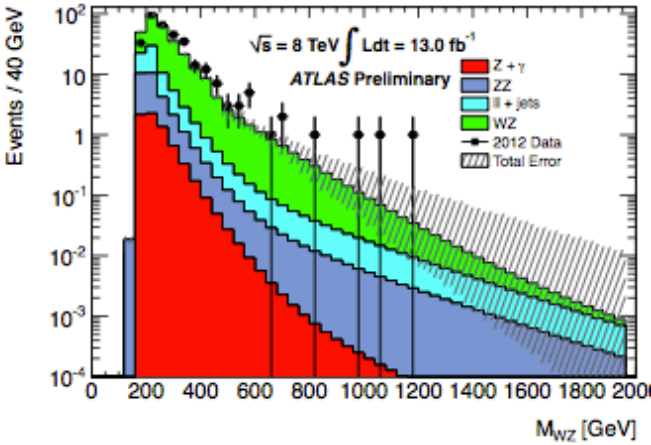
Exotics: ee , μμ, WZ

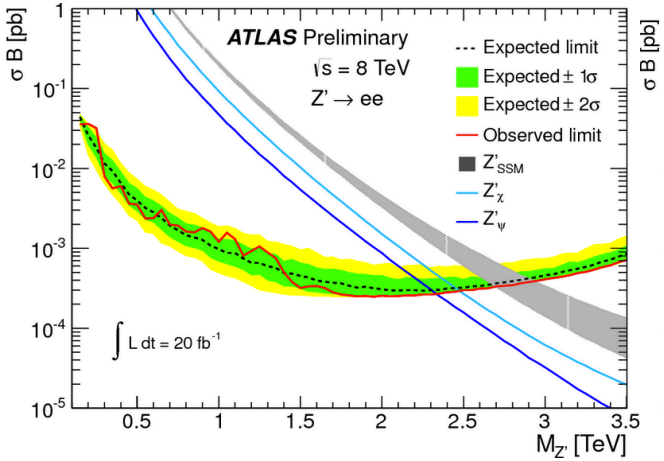
ATLAS-CONF-2013-017

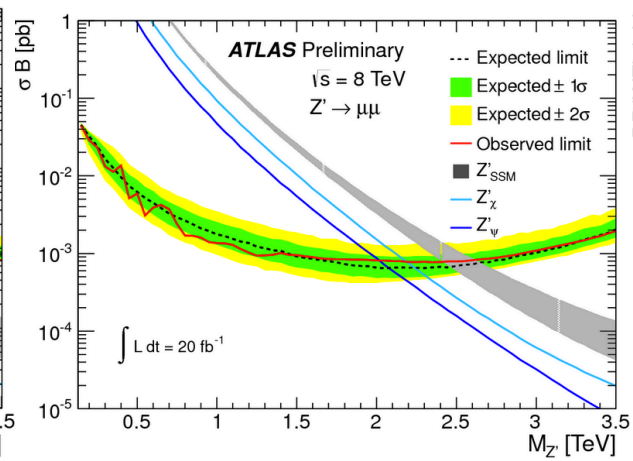


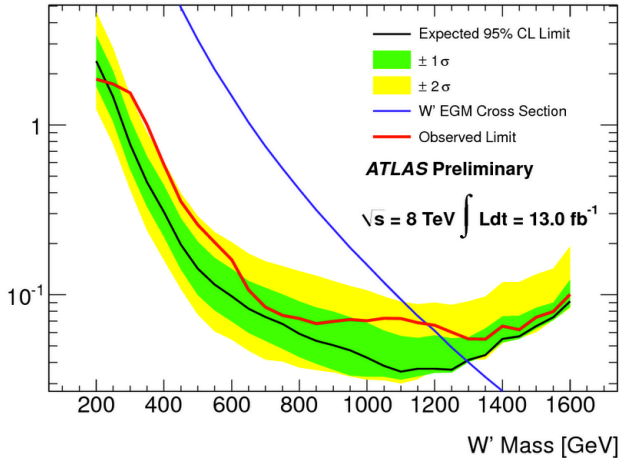


ATLAS-CONF-2013-015



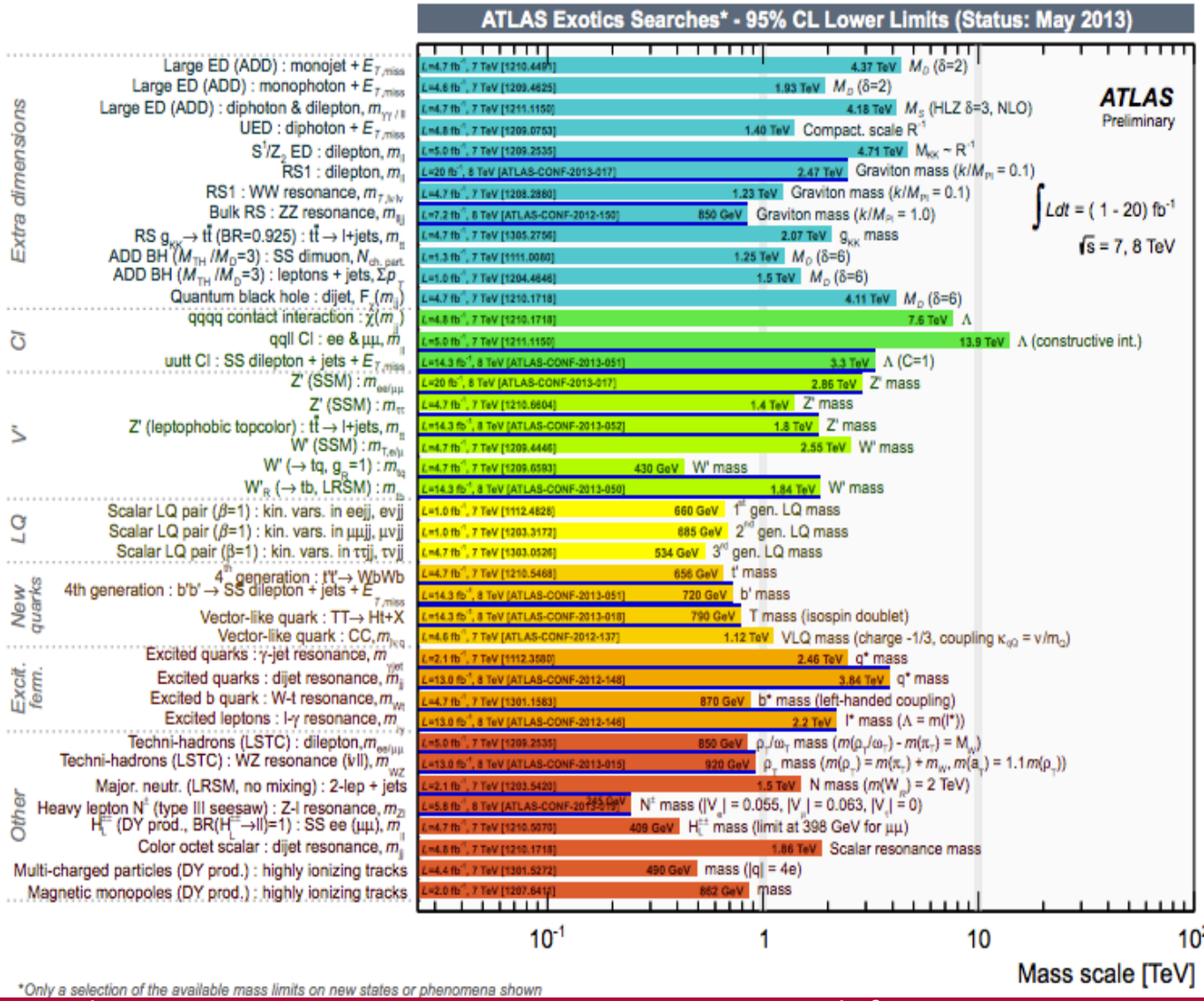






Limits (95% CL): M(Z') > 2.79 TeV (ee); M(Z') > 2.48 TeV (μμ); M(Z') > 2.86 TeV (combined)
M(W')> 1.18 TeV

Searches for New physics
Specific models and model independent



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

Exotics Models:

Extra dimensions:
- RS KK Graviton (dibosons, dileptons, diphotons)
- RS KK gluons (top antitop)
- ADD (monojets, monophotons, dileptons, diphotons)
- KK Z/gamma boosns (dileptons)

Grand Unification symmetries (dielectons, dimuons, ditaus)
Leptophobic topcolor Z' boson (dilepton ttbar, l+j, all had)
SB- color octet scalars (dijets)
String resonance (dijets,)
Benchmark Sequential SM Z',W'
W' (lepton+MET, dijets, tb)
W* (lepton+MET, dijets)
Quantum Black Holes (dijet)
Black Holes (l+jets, same sign leptons)
Technihadrons (dileptons, dibosons)
Dark Matter
- WIMPs (Monojet, monophotons)

Excited fermions
- q*, Excited quarks (dijets, photon+jet)
- l*, excited leptons (dileptons+photon)

Leptoquarks (1st, 2nd, 3rd generations)
Higgs -> hidden sector (displaced vertices, lepton jets)
Contact Interaction
- llqq CI
- 4q CI (dijets)

Doubly charged Higgs (multi leptons, same sign leptons)
4th generation
- t'->Wb, t'->ht, b'-Zb, b'->Wt (dileptons, same sign leptons, l+J)

VLQ-Vector Like quarks
Magnetic Monopoles (and HIP)
Heavy Majorana neutrino and RH W

LHC Time-line

2009 — Start of LHC

2010 - 2012 — Run I: pp 7-8TeV, Ramp to lumi. $10^{33}cm^{-2}s^{-1}$, 50 ns, 25 fb^{-1}; Pb Pb,pPb

2013 - 2014 — Long LHC 1 shut down: prepare for design energy and nominal Luminosity

New pixel B layer

2015 - 2017 — Run II: 14 TeV Ramp up to nominal lumi. $10^{34}cm^{-2}s^{-1}$, 50-100 fb^{-1},25ns

2018 — LS2 : Injector and LHC Phase-I upgrade to go to ultimate luminosity

New μ wheel,DAQ

2019 –2021 — Run III: 14 TeV, Ramp up to $2x10^{34}cm^{-2}s^{-1}$ nominal, 100 fb^{-1}/ year, 25ns

2022 — LS3: High lumi. LHC. New focusing magnets for very high luminosity with levelling

New tracker calo readout

2030 ? — Run IV: luminosity ~$5x10^{34}cm^{-2}s^{-1}$Collect data until > 3000 fb^{-1}

Conclusions

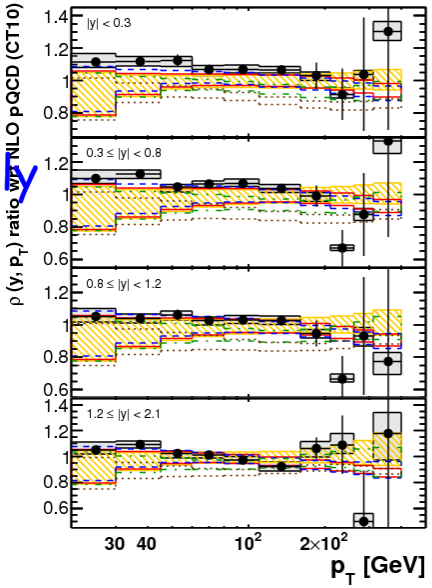
- ☑ Excellent performance of LHC and very exciting times for the ATLAS collaboration:
  - Very good detector performance
  - High efficiency of data taking; computing; physics analysis
- Finding the new boson is a great physics result, however if it just looks like a minimal SM Higgs boson – the simplest possible realization of the EW symmetry breaking – it leaves many unanswered questions – the gauge hierarchy problem will be still with us.
- In many cases, the measurements are systematics limited:

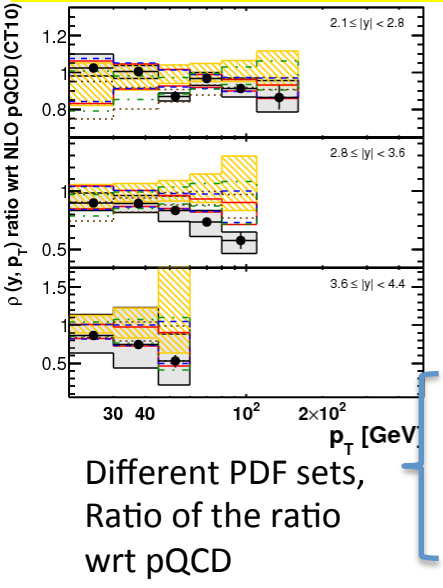
  we are entering the era of precision measurements at the LHC
- Searches for New Physics in a vast number of topologies and theoretical scenarios
- Up to now, all the data are consistent with Standard Model
- LHC and ATLAS are taking a short break until 2015 to come back at 13-14TeV at the new energy frontier giving new results and hopefully surprises

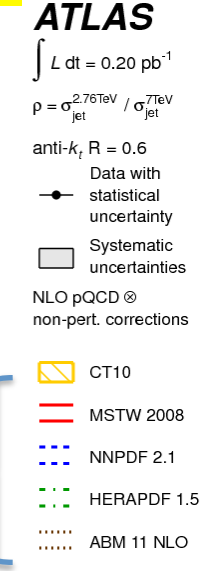
Inclusive Jet Production ratio: constrain PDFs

- ☑ Ratio of inclusive jet Pt spectra cross sections at 2 different energies:
- ☑ 2.76TeV (2010) and 7.0 TeV (2011)
- ☑ Ratio of 2 results reduces strongly the largest experimental error coming from JES.

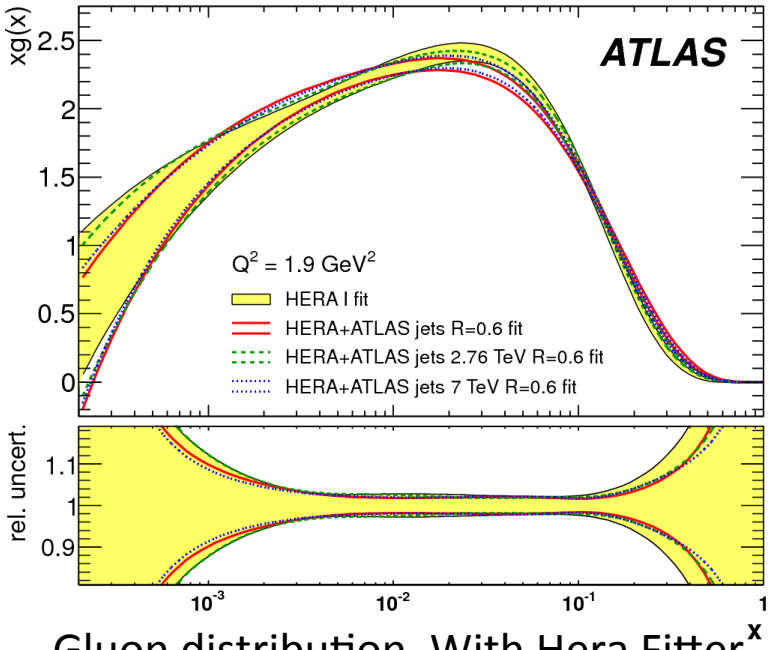
EPJC (2013) 73 2509







Different PDF sets, Ratio of the ratio wrt pQCD



Gluon distribution, With Hera Fitter

- ☑ Two different beam energies probe different x and Q^2 values for the same pt and η ranges → theoretical uncertainties due to PDFs do not cancel in the ratio: extra sensitivity
- ☑ Gluon distribution becomes harder with ATLAS jet data

ATLAS-CONF-2012-128

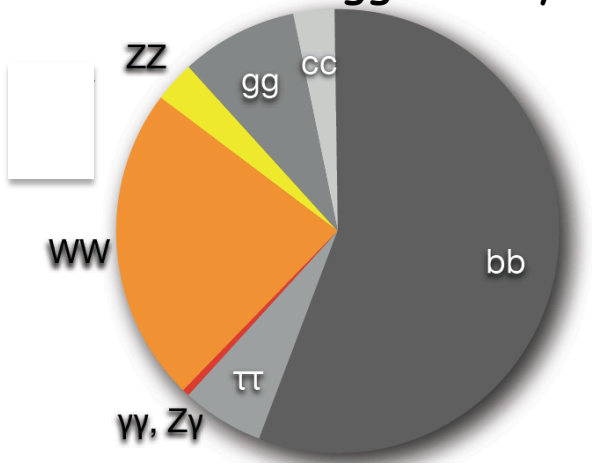
Diboson physics

- Importance of di-boson production: significant and irreducible background for Higgs and exotica searches:

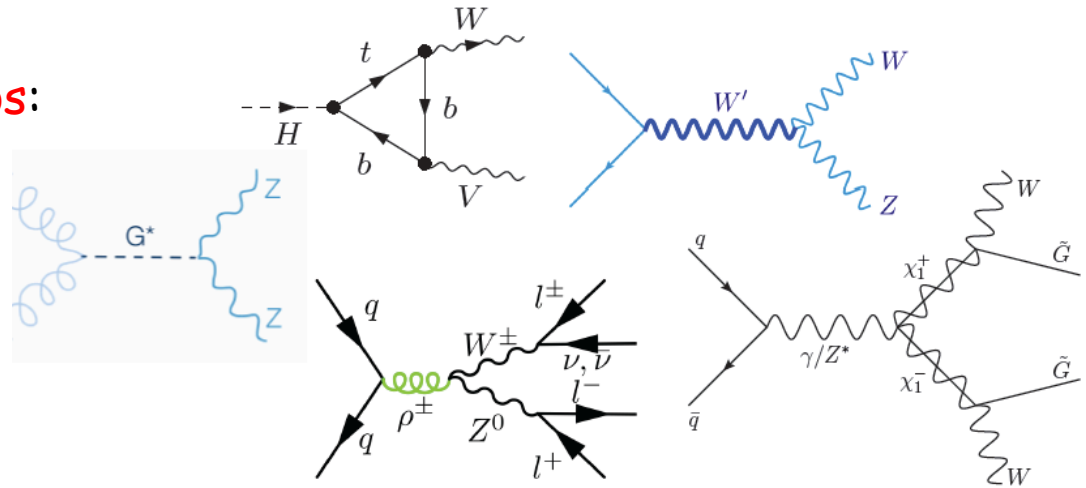
  for m_H = 125 GeV, H→VV is 25%

- Dibosons sensitive to Triple Gauge Couplings. Deviations could indicate physics beyond SM, as neutral TGC.
  - WWg and WWZ : allowed
  - ZZg, Zyy and ZZZ are forbidden at tree level

Higgs decays



- Present in many BSM scenarios:
  - Extra Vector Bosons
  - Extra Dimensions
  - SUSY
  - Technicolor
  - Extended Higgs sector



Heavy Flavour: J/Ψ+W production

- ☑ Probes of charmonium production mechanisms in hadronic collisons
- ☑ Sensitive to multiple parton interactions
- ☑ Look at final states W-> μ ν and J/Ψ -> μ μ
- ☑ Unbinned maximum likelihood fit gives $29.2\ ^{+7.5}_{-6.5}$ events: 5.3σ
- ☑ Estimate Double Parton Scattering (DPS) contribution from ansatz (based on the observation of DPS in W+2jets [**ATLAS, New J. Phys 15 (2013) 033038**])
- ☑ Compare DPS-subtracted value to theoretical predictions
- ☑ Uniform component compatible with DPS, and a peaked component (where P_T is balanced) suggestive of real associated production.

ATLAS-CONF-2013-042