

ATLAS Physics Results with 2010 Data and Preliminary Results with 2011 Data

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Michigan State University

on behalf of
the ATLAS Collaboration

2nd International Conference on Particle Physics
In Memoriam Engin Arik and Her Colleagues
Doğuş University, Istanbul
20th June 2011



Overview

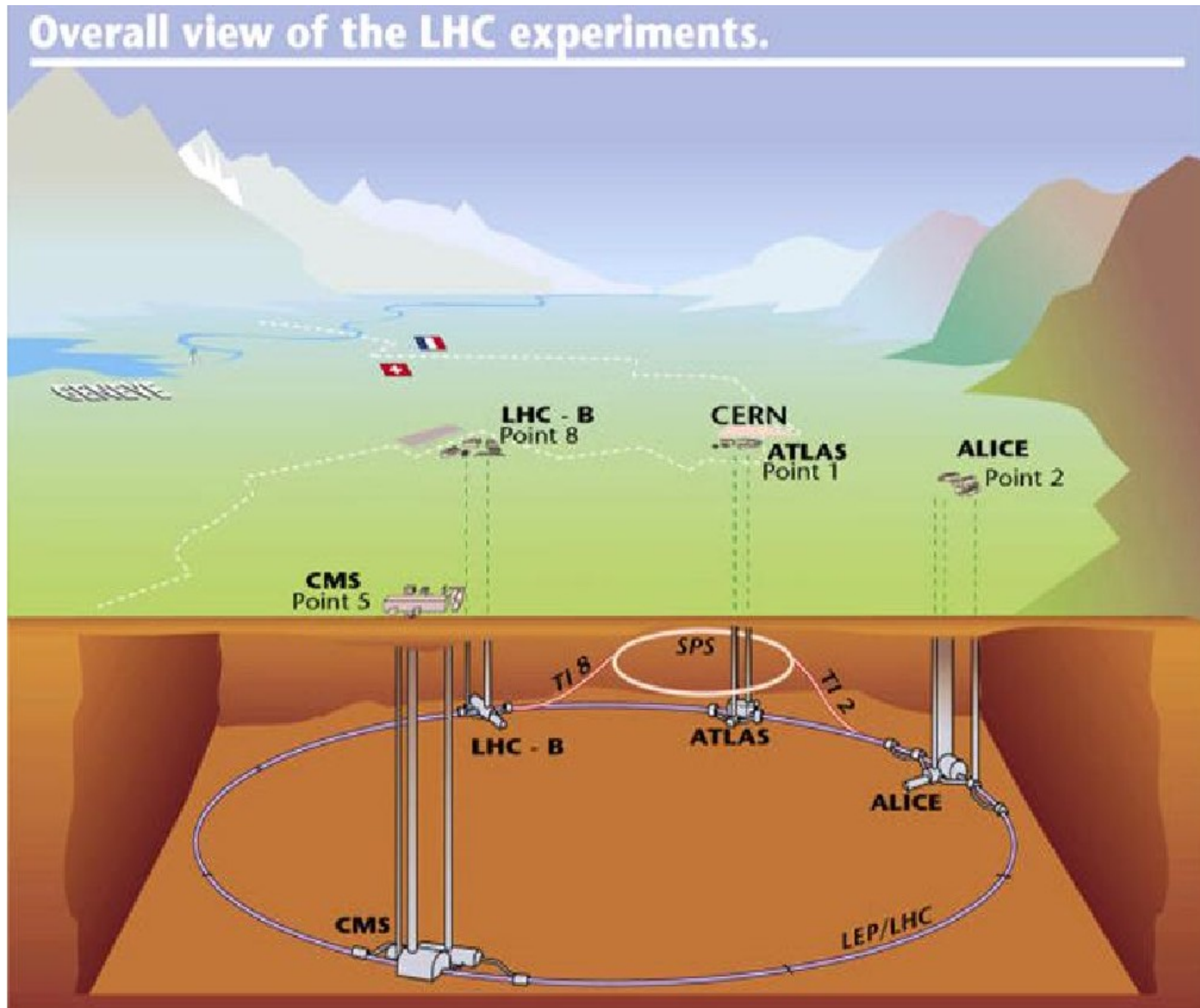
→ The ATLAS Experiment

- Data Taking Performance
- Detector Performance

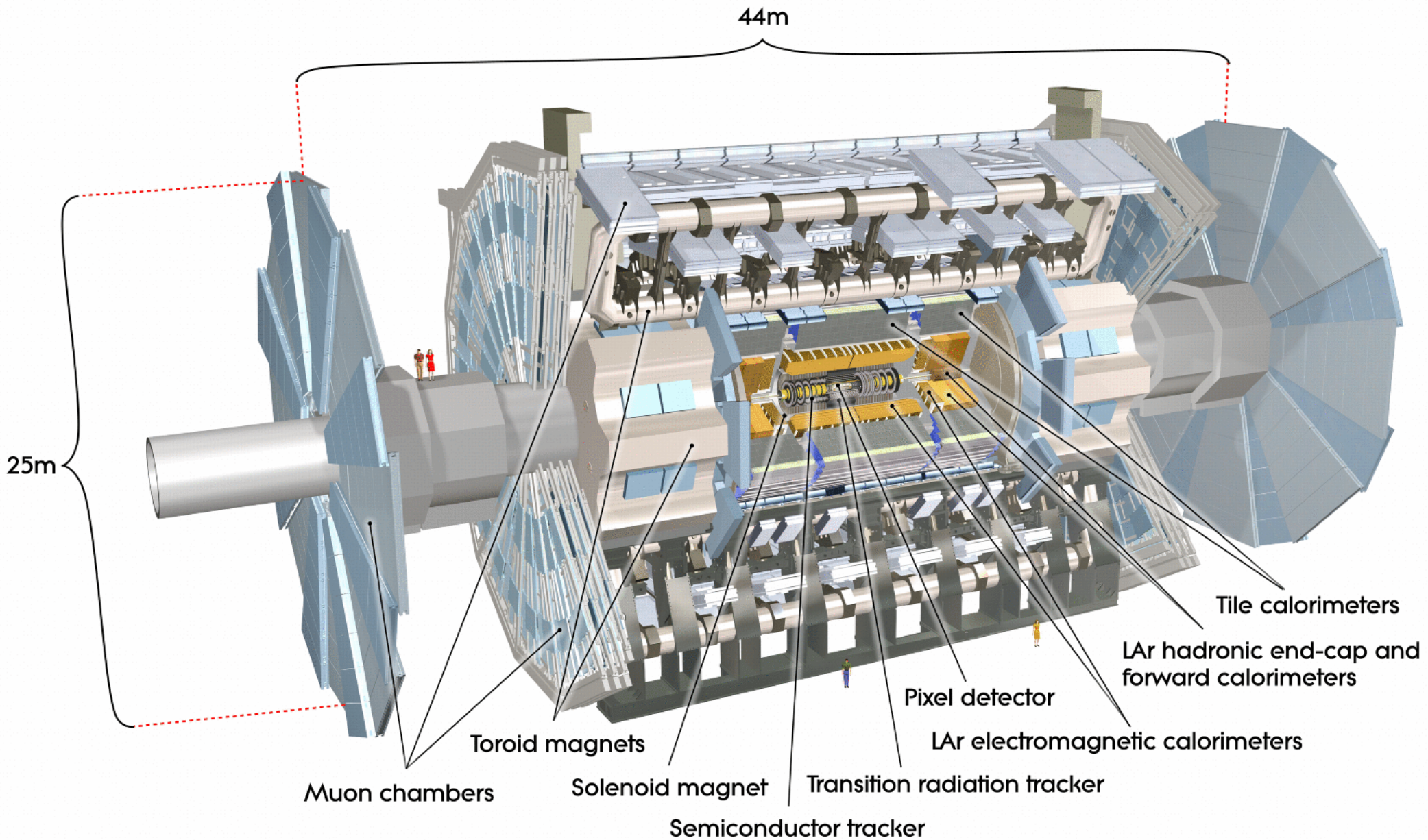
→ Physics Results

- Jets, W, Z
- Top
- Higgs
- SUSY
- New Physics
- Heavy Ion

The ATLAS Experiment



The ATLAS Detector



Detector Status

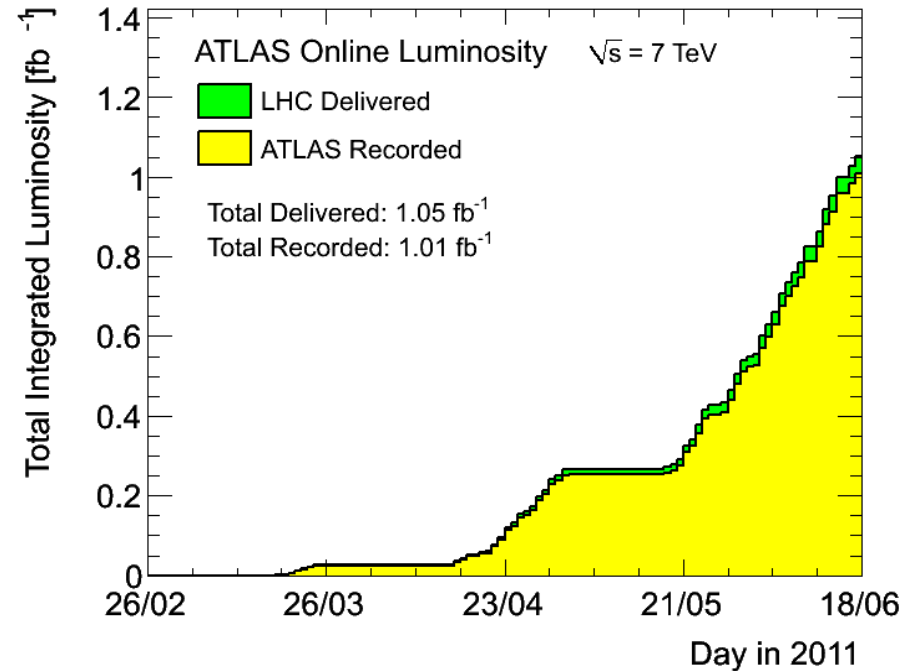
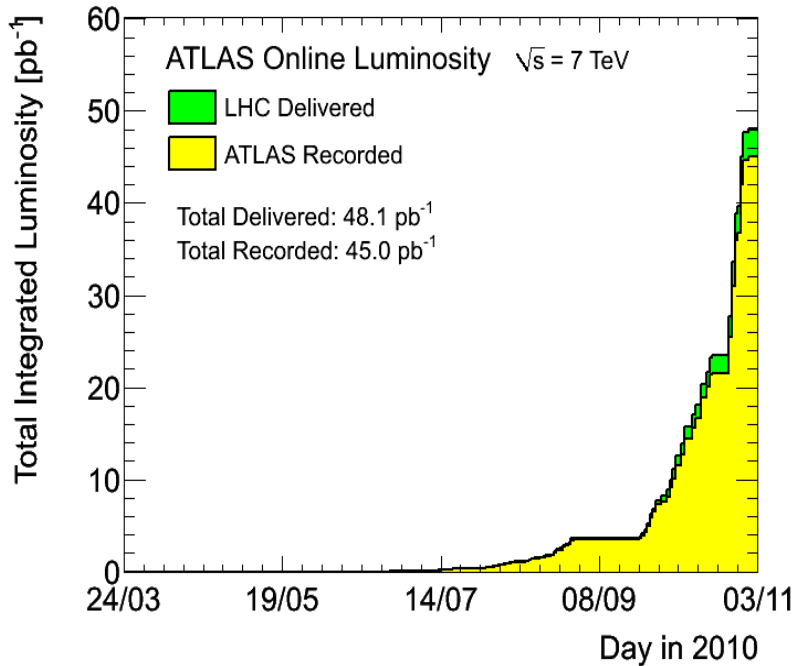
ATLAS Detector Status

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	96.9%
SCT Silicon Strips	6.3 M	99.1%
TRT Transition Radiation Tracker	350 k	97.5%
LAr EM Calorimeter	170 k	99.5%
Tile calorimeter	9800	97.9%
Hadronic endcap LAr calorimeter	5600	99.6%
Forward LAr calorimeter	3500	99.8%
LVL1 Calo trigger	7160	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.8%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	98.4%

For more details...

- N. Benekos, *ATLAS Detector Status and Operations, Improvements during Shutdown, and 2011 Data Taking*
 - Tuesday, 11:50h
- T. Cornelissen, *ATLAS Inner Detector Performance at LHC*
 - Tuesday, 17:00h
- A. Bingul, *ATLAS TRT and its Performance at LHC*
 - Thursday 14:00h
- A. Salzburger, *ATLAS Detector Upgrade Plans and Perspectives*
 - Thursday 9:50h

Recorded Luminosity



One LHC fill delivers now around the same luminosity as the whole 2010 data taking Period.

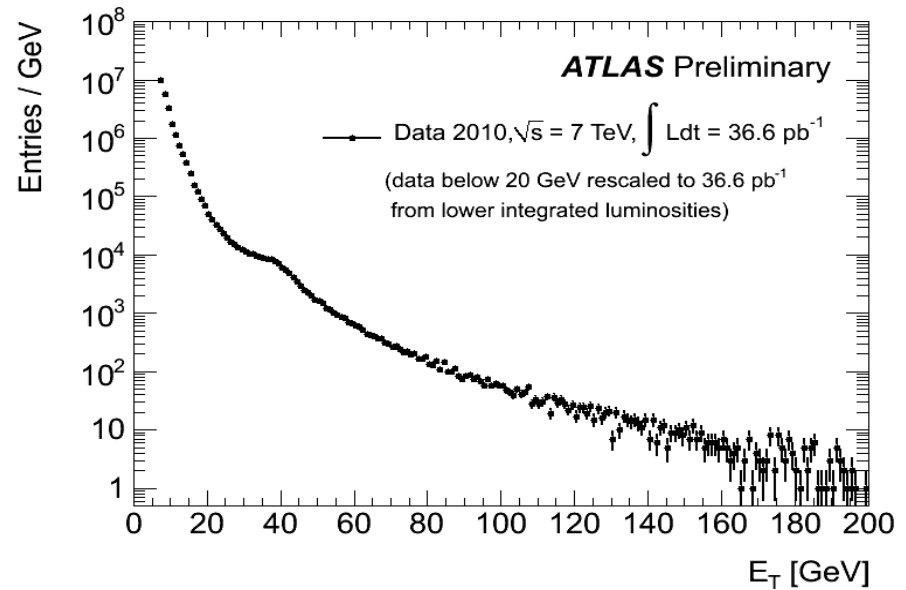
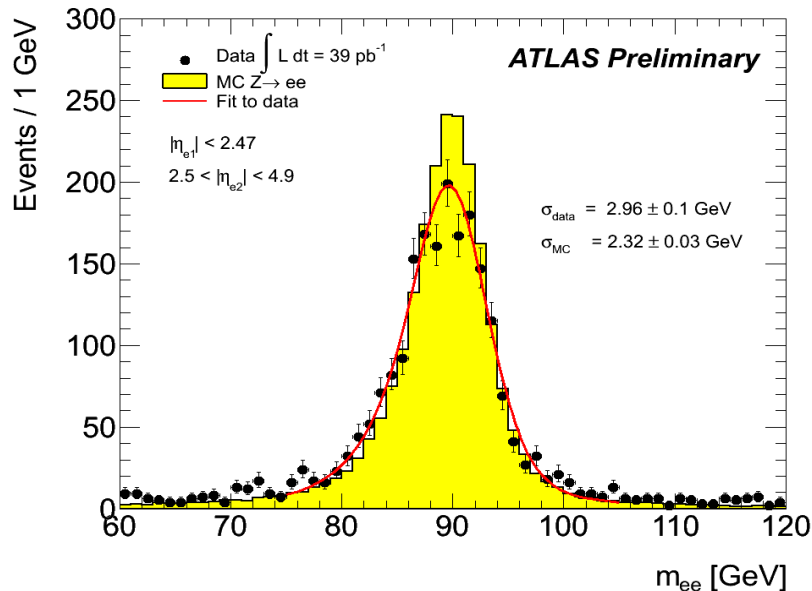
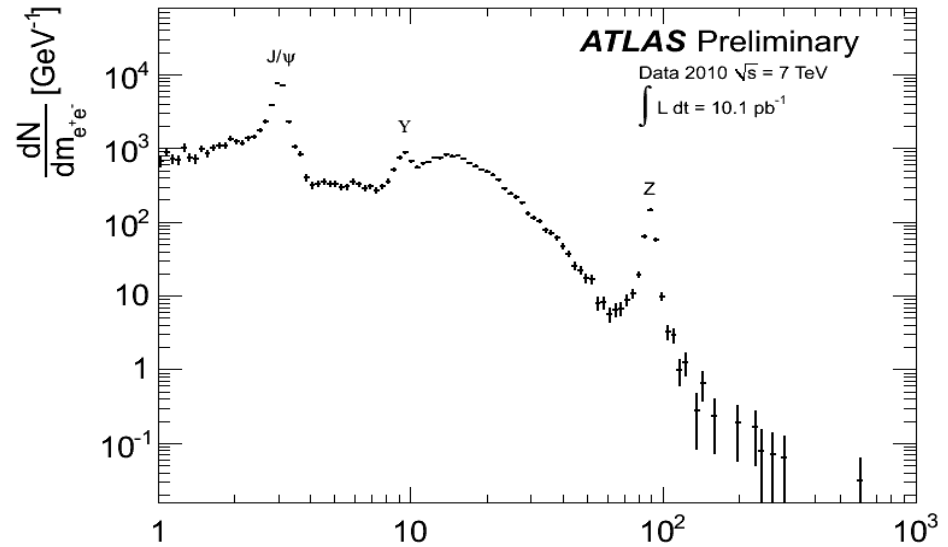
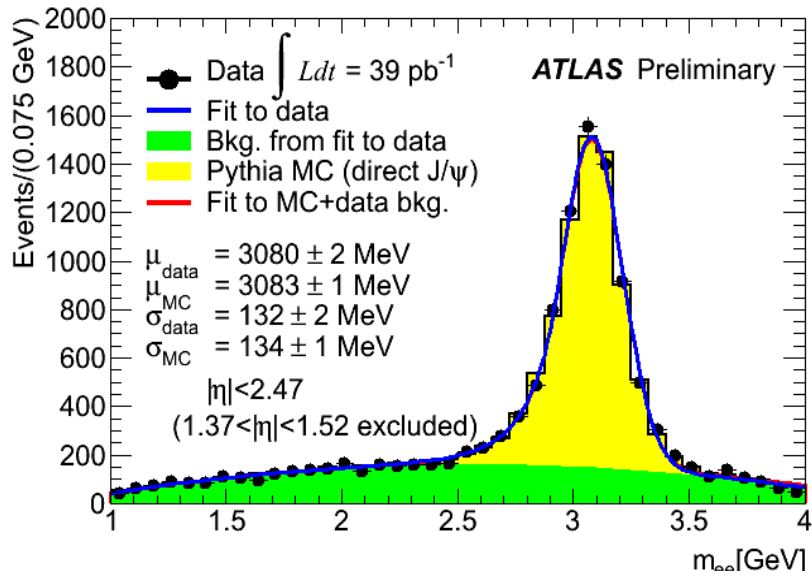
Overall data taking efficiency: ~94 %

Inner Tracking Detectors			Calorimeters				Muon Detectors				Magnets	
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.8	99.5	100	89.3	92.7	94.3	99.5	100	99.5	100	99.9	98.5	97.9

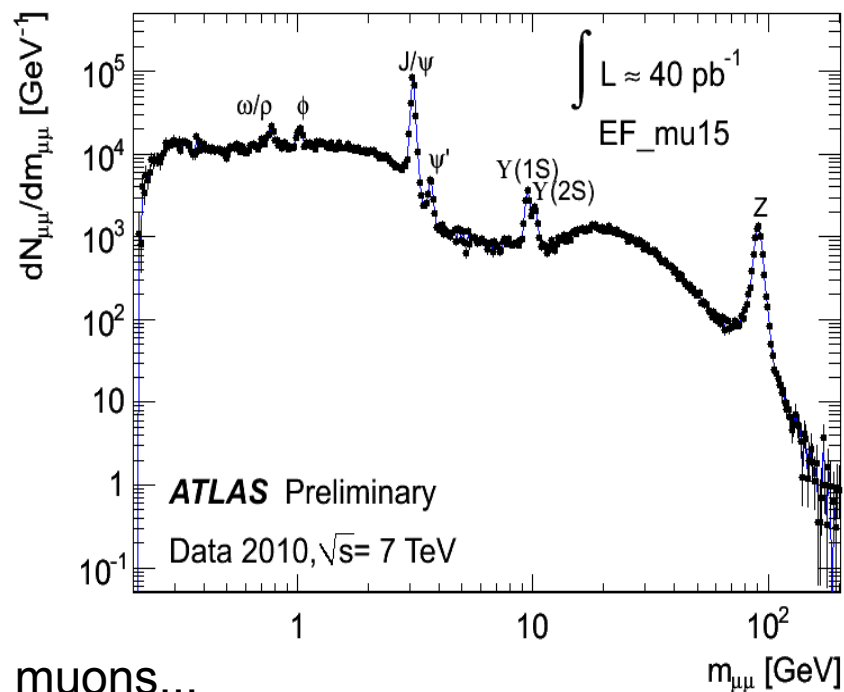
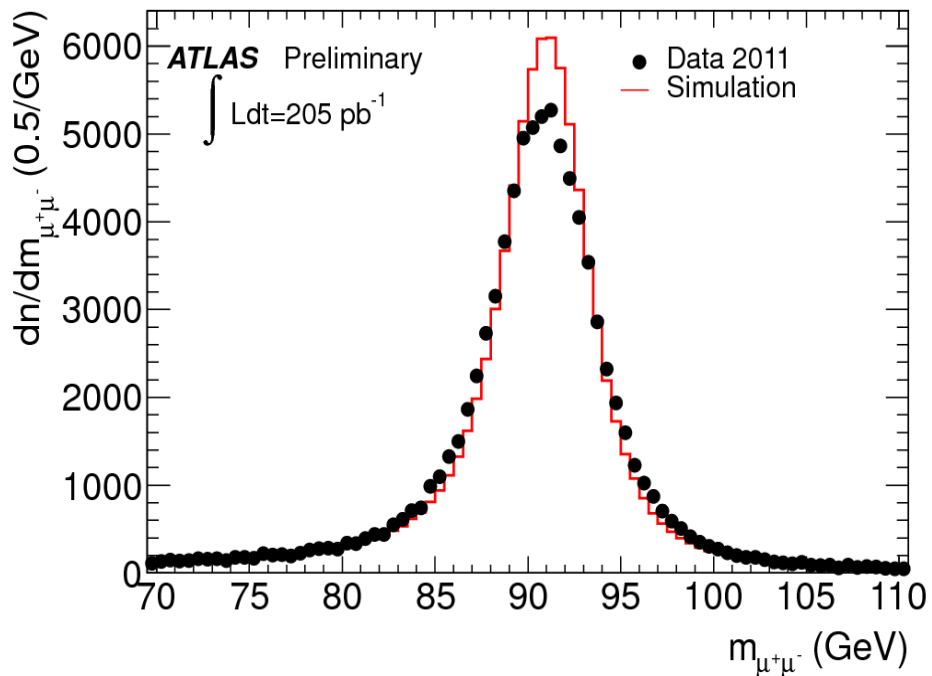
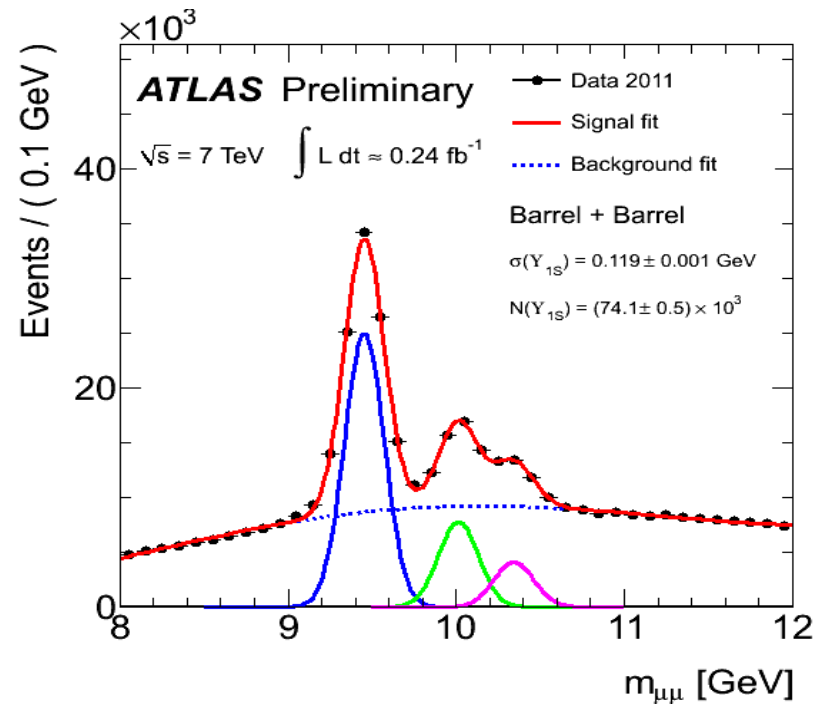
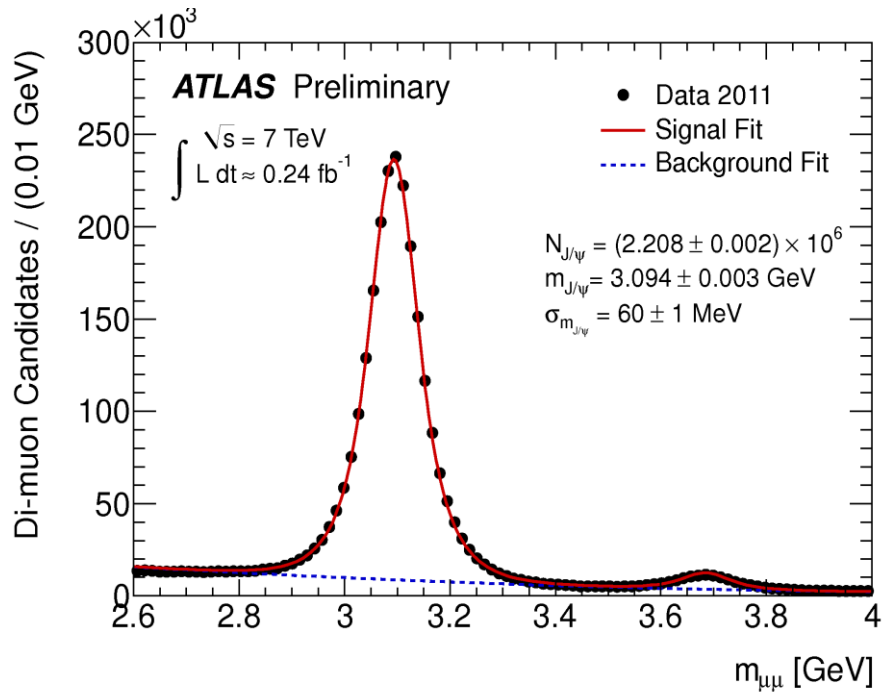
Luminosity weighted relative detector uptime and good quality data delivery during 2011 stable beams in pp collisions at $\sqrt{s}=7$ TeV between March 13th and June 6th (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future. The magnets were not operational for a 3-day period at the start of the data taking.

Standard Model Physics

Rediscovering the Standard Model

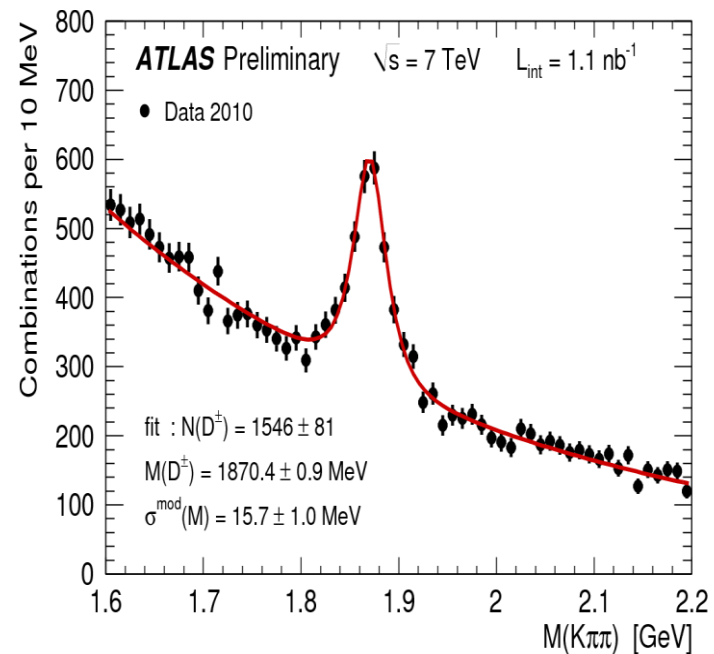
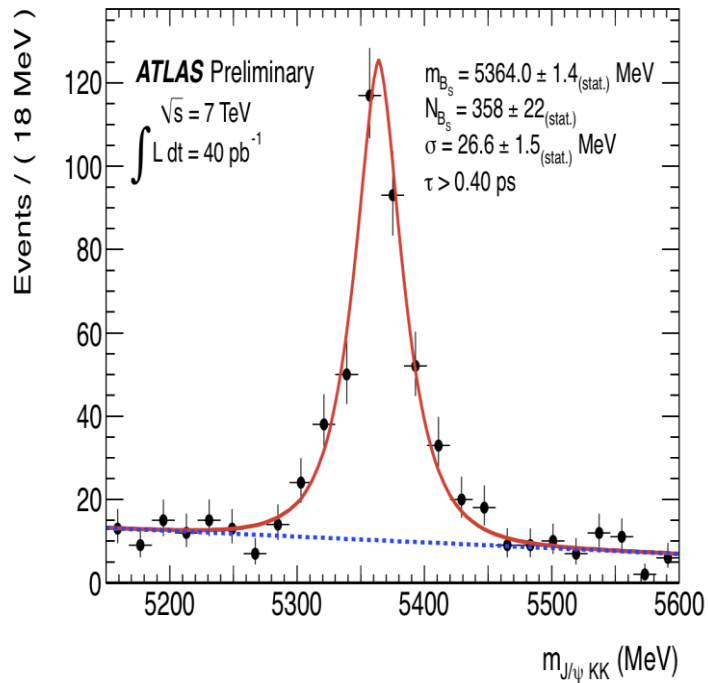
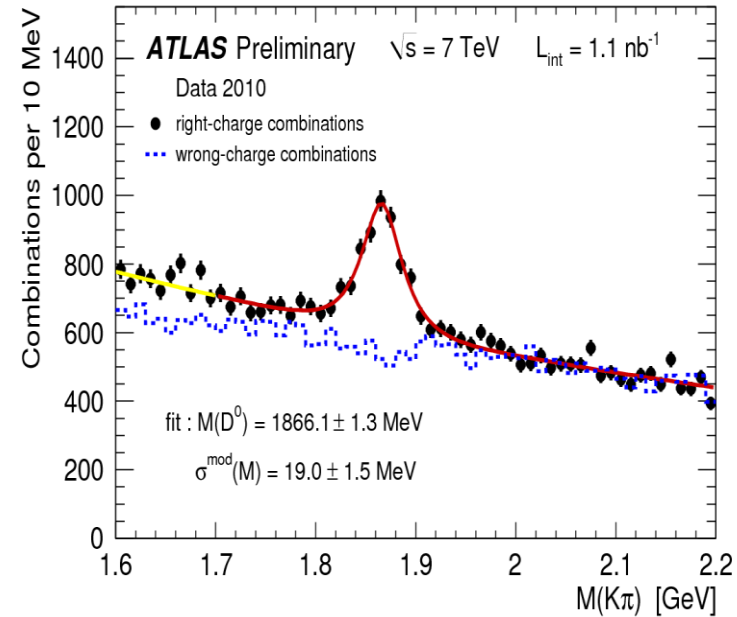
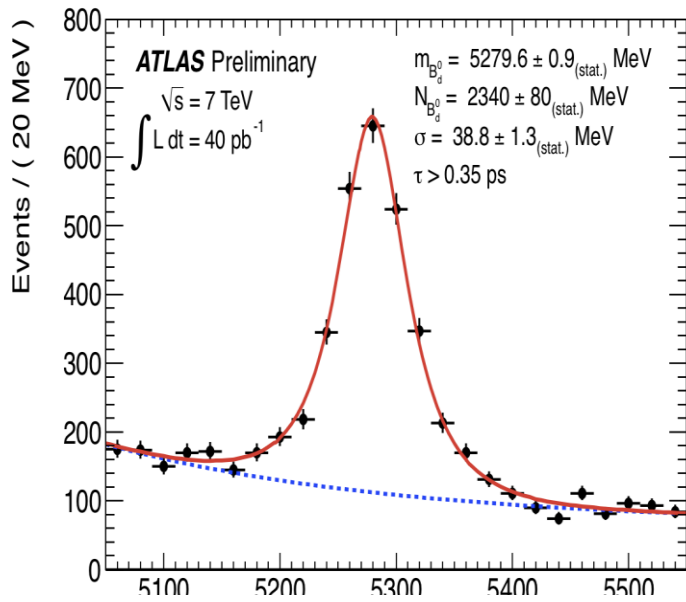


With electrons...



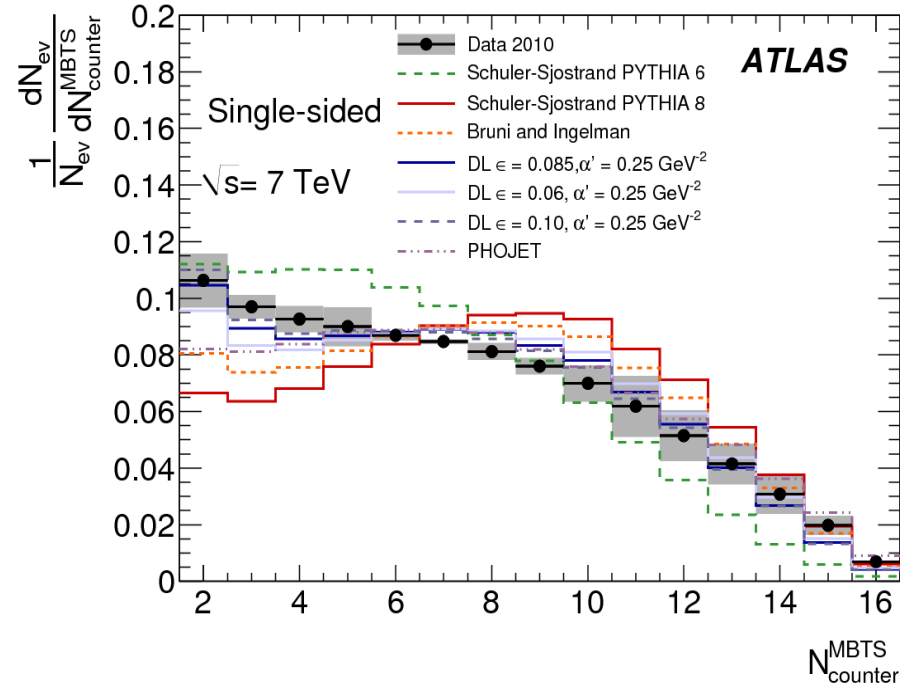
And muons...

B and D Mesons



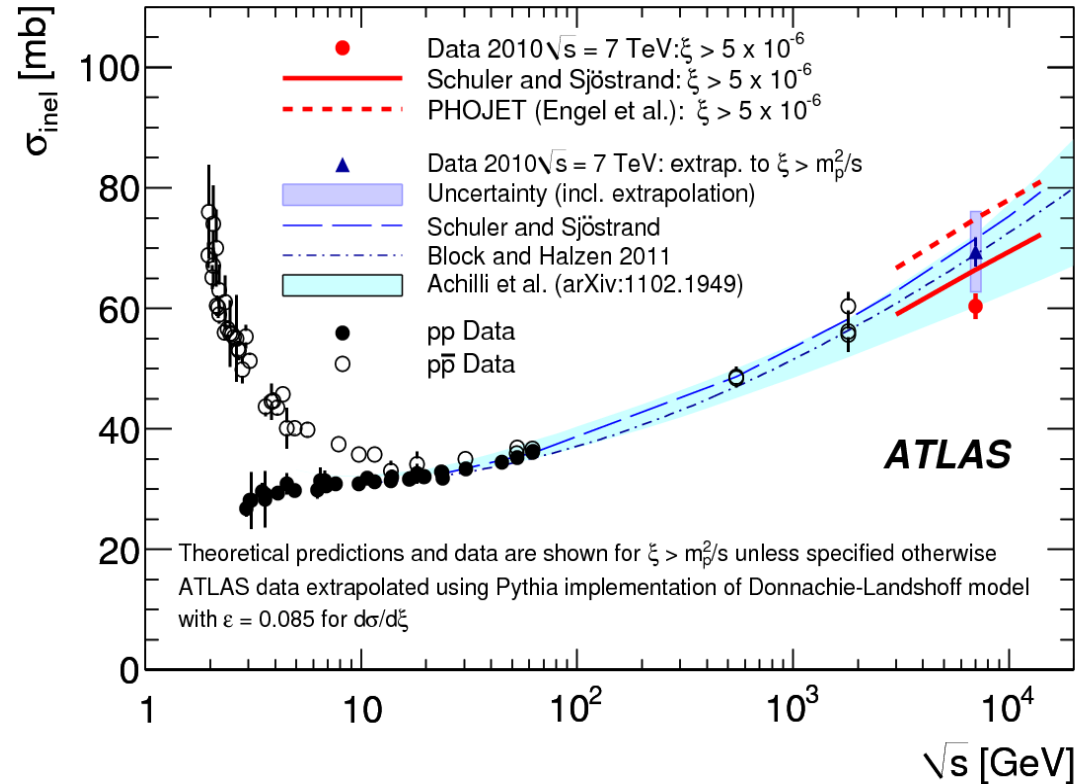
Inelastic pp Cross-Section

Selected online by minimum bias trigger (MBTS)

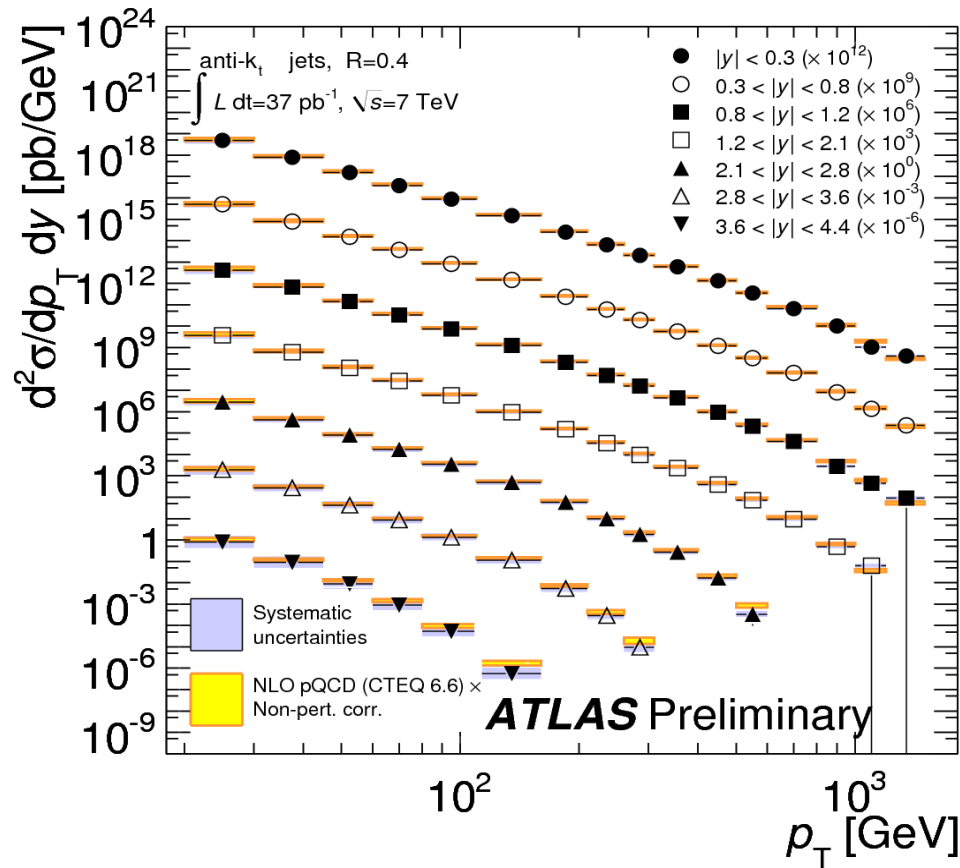


$$L = 20 \mu\text{b}^{-1}$$

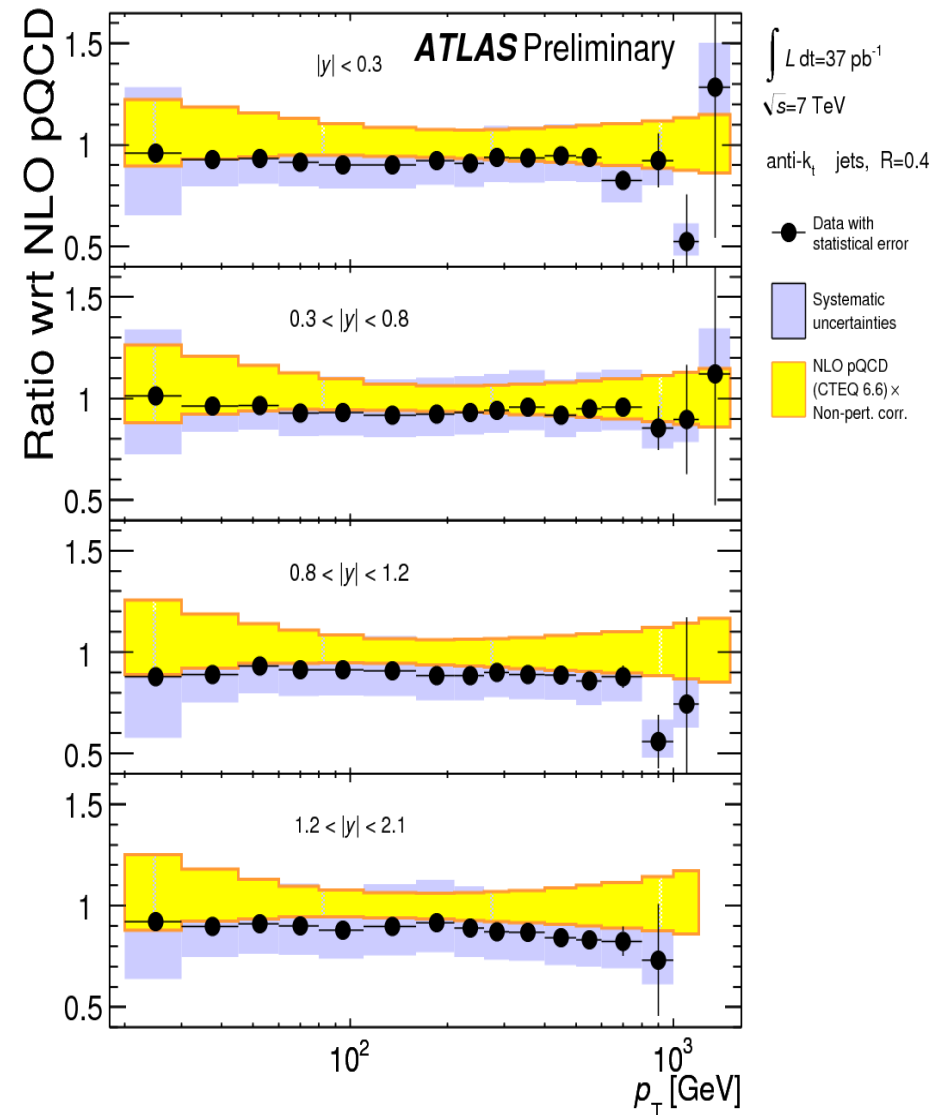
$$\sigma = 60.3 \pm 2.1 \text{ mb for } \xi > 5 \times 10^{-6}$$



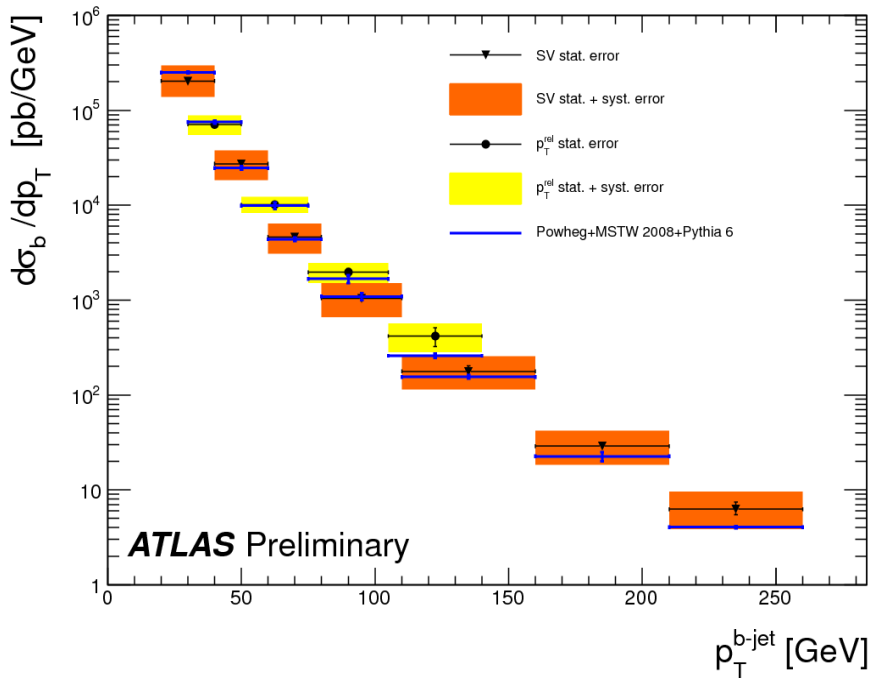
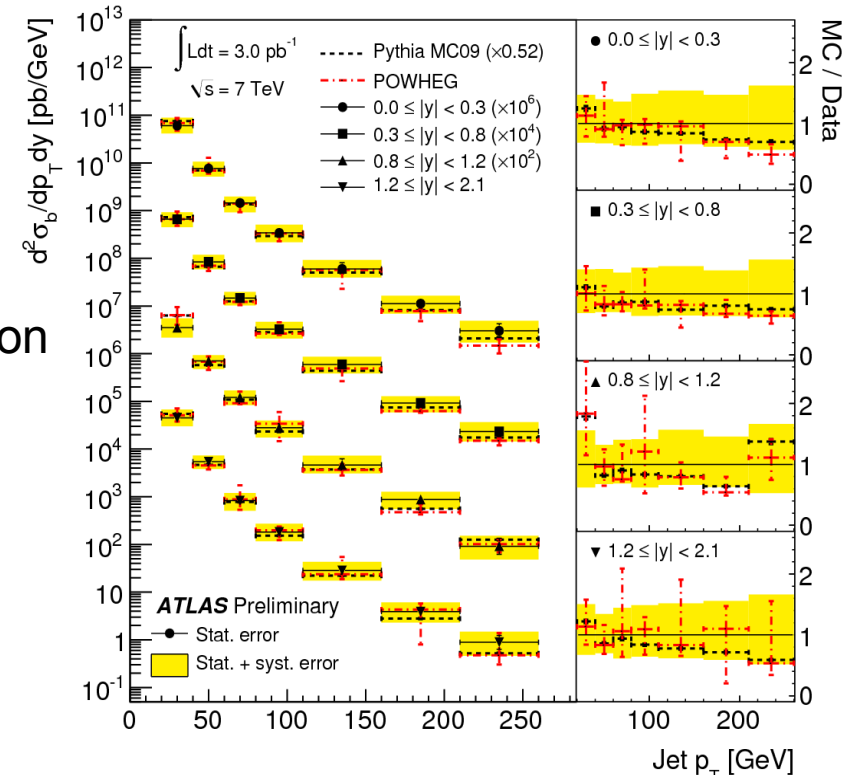
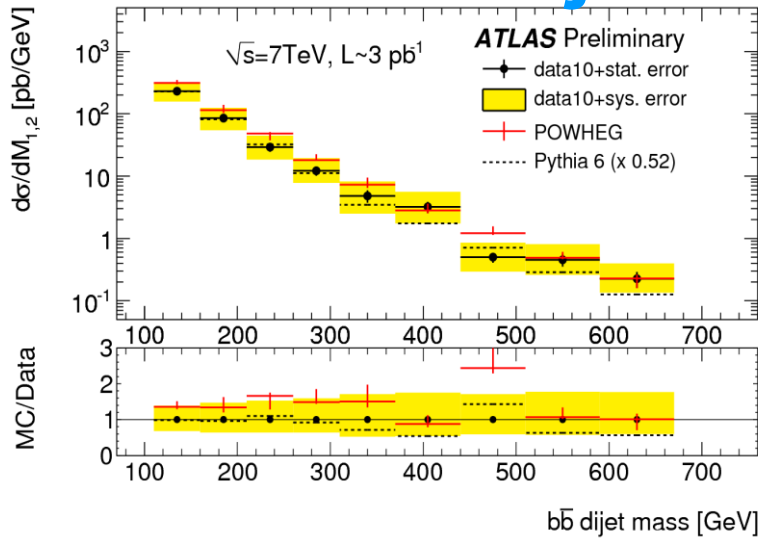
Inclusive Jet and di-jet Cross Section



Anti-kT jet algorithm with $R = 0.4$ and 0.6
 Compared to NLO QCD predictions over
 wide range and in new kinematic regime.



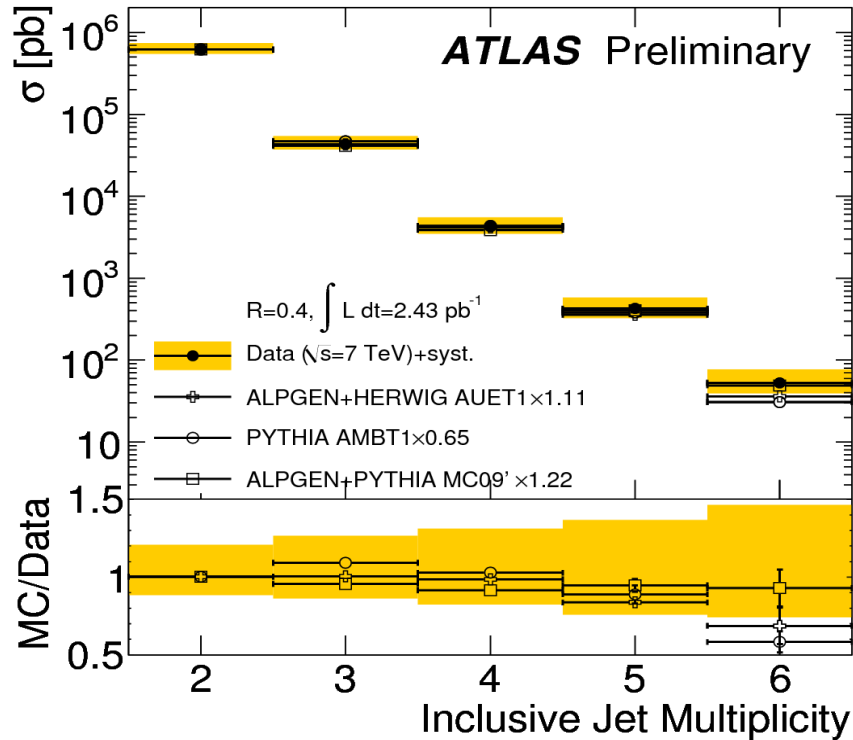
B jet Cross Section



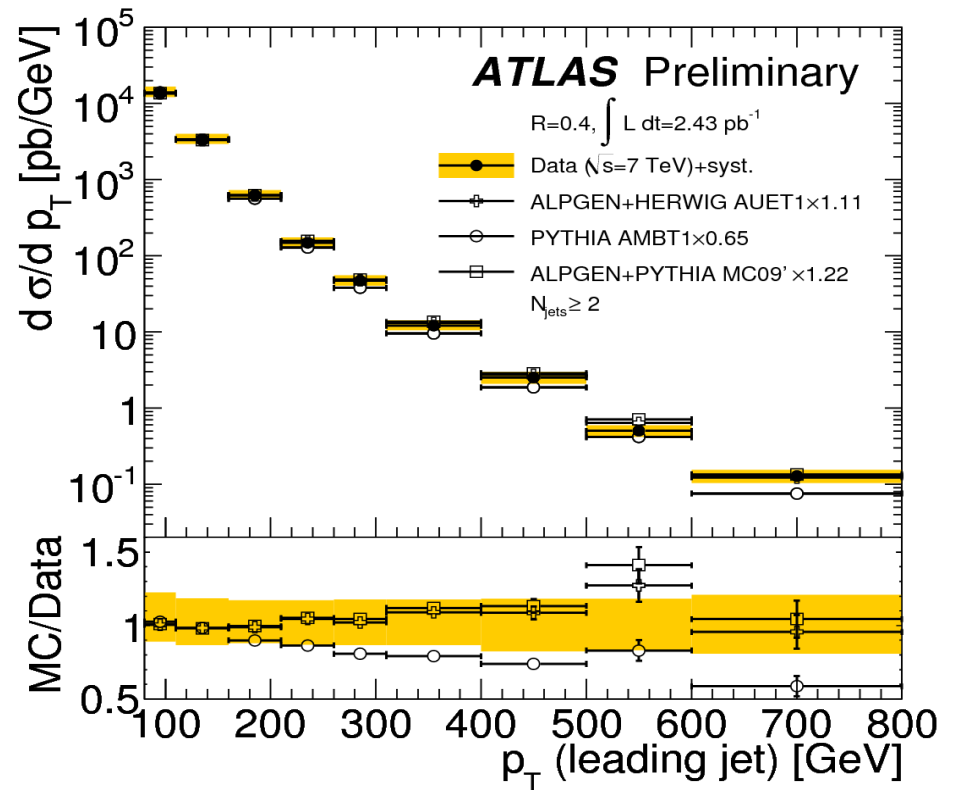
Also measured with muons in jets using $p_{T,\text{rel}}$ of muons to determine b purity of sample.

Comparison with displaced vertex analysis.

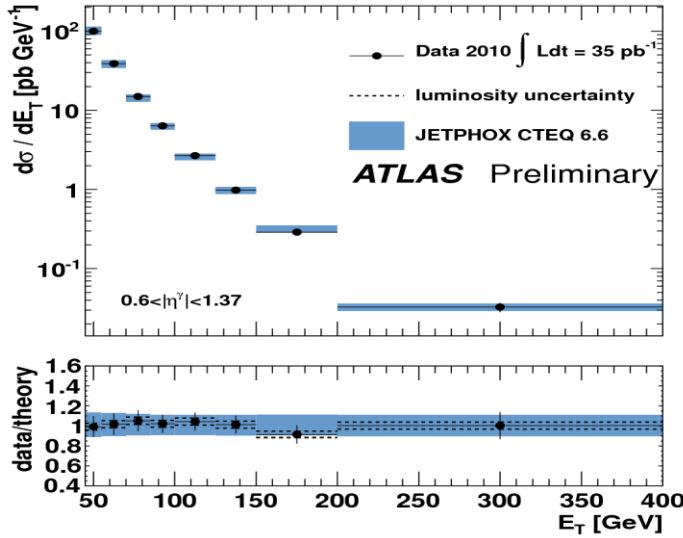
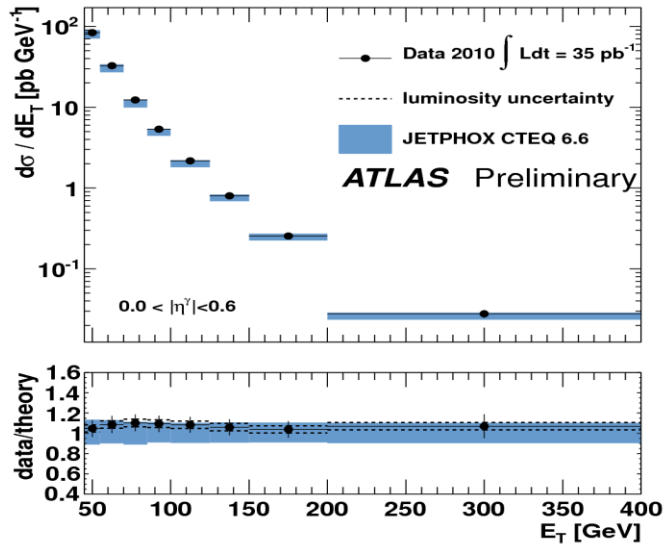
Multi-Jet Cross Section



Inclusive multi-jet production
Compared to LO QCD MC

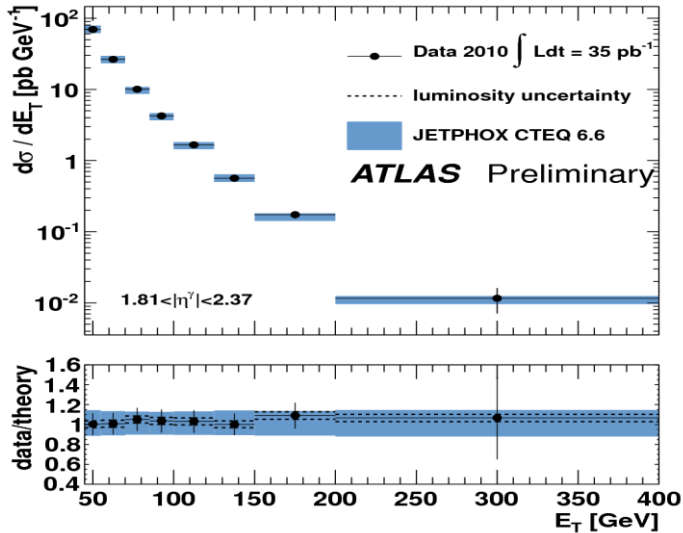
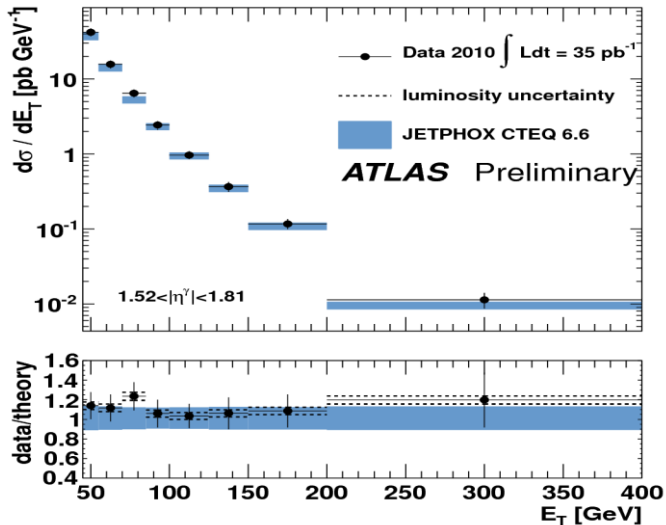


Direct Photon Cross Sections



$|\eta| < 1.37$

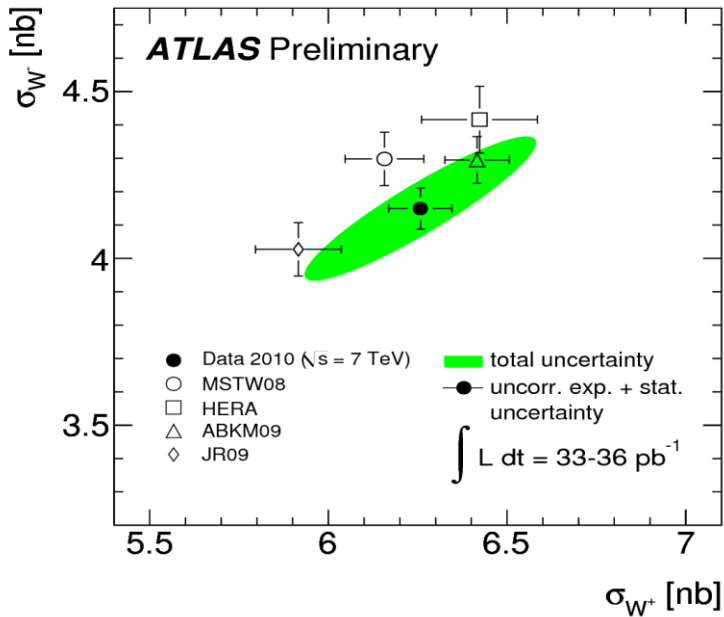
Reject photons from π^0 decays and conversions.



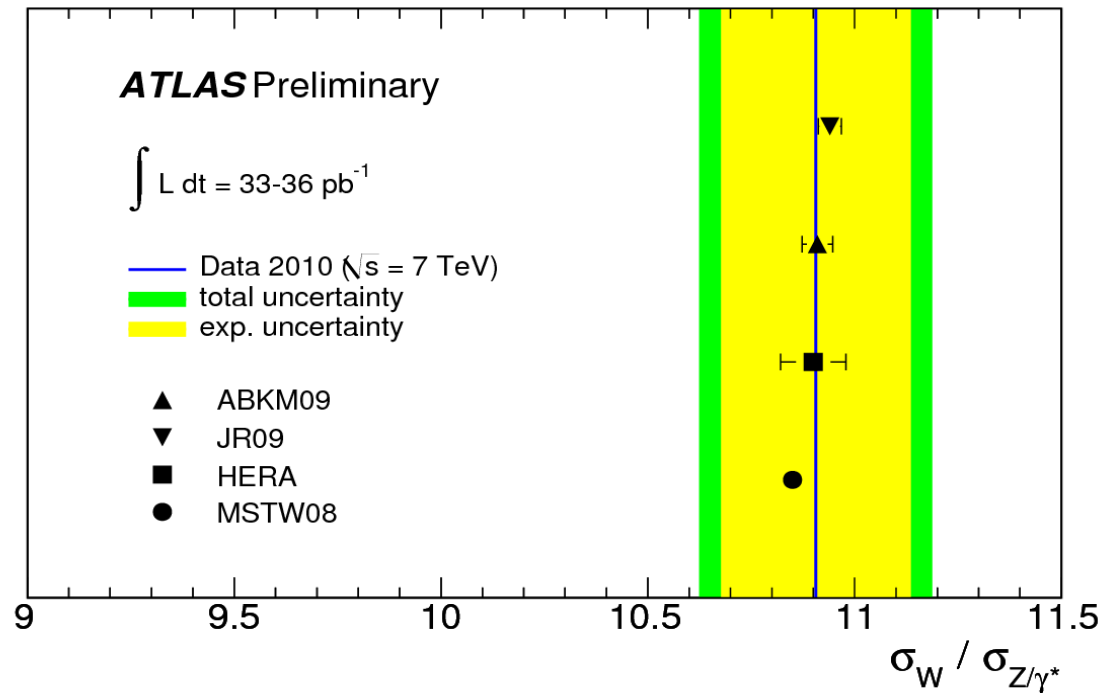
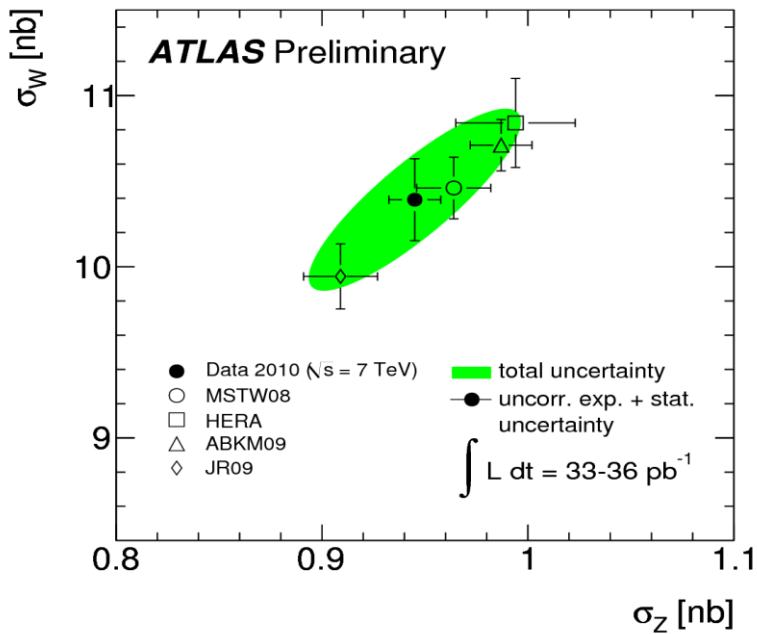
$1.52 < |\eta| < 2.37$

Compared to NLO QCD calculations

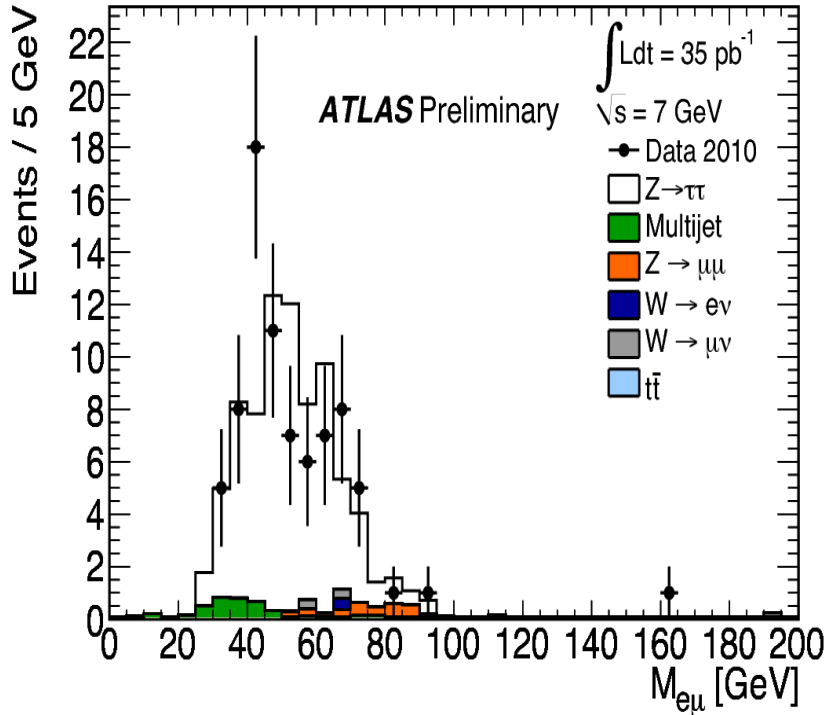
Total W^\pm and Z/γ^* Cross Sections and their Ratios



	$\sigma_{W^{(\pm)}}^{\text{tot}} \cdot \text{BR}(W \rightarrow \ell\nu)$ [nb]
W^+	$6.257 \pm 0.017(\text{sta}) \pm 0.152(\text{sys}) \pm 0.213(\text{lum}) \pm 0.188(\text{acc})$
W^-	$4.149 \pm 0.014(\text{sta}) \pm 0.102(\text{sys}) \pm 0.141(\text{lum}) \pm 0.124(\text{acc})$
W	$10.391 \pm 0.022(\text{sta}) \pm 0.238(\text{sys}) \pm 0.353(\text{lum}) \pm 0.312(\text{acc})$
$\sigma_{Z/\gamma^*}^{\text{tot}} \cdot \text{BR}(Z/\gamma^* \rightarrow \ell\ell)$ [nb], $66 < m_{ee} < 116$ GeV	
Z/γ^*	$0.945 \pm 0.006(\text{sta}) \pm 0.011(\text{sys}) \pm 0.032(\text{lum}) \pm 0.038(\text{acc})$

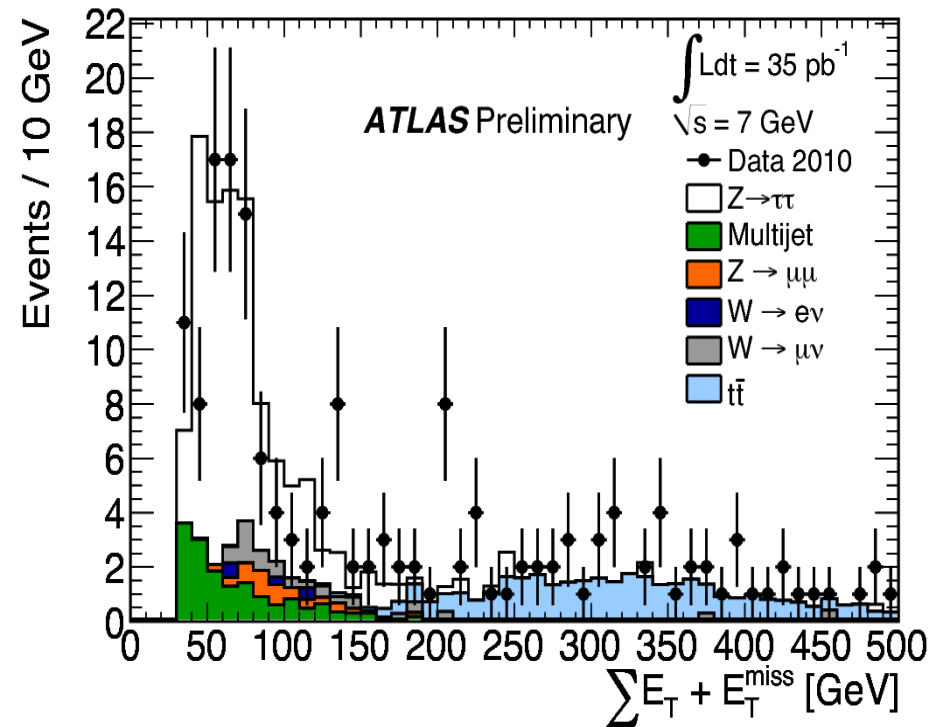


Observation $Z \rightarrow \tau\tau \rightarrow e\mu + 4\nu$

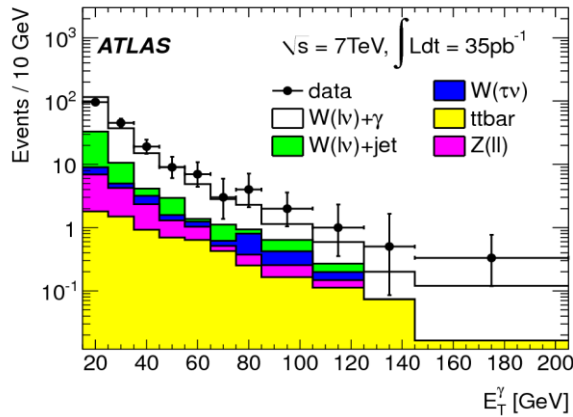


Compatible with SM value:
 $69.3 \pm 5.1 \text{ (stat.)} \pm 15.1 \text{ (sys.)}$

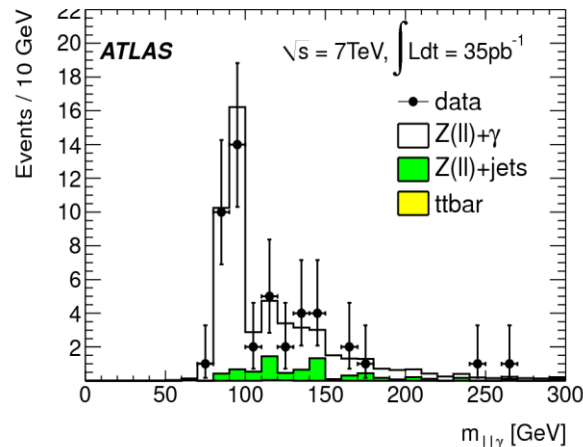
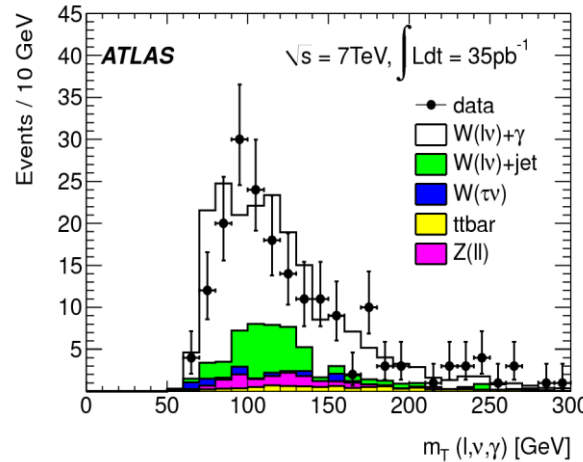
75 events selected with
exp background of $6.4 \pm 3.7 \text{ (stat.)} \pm 0.9 \text{ (sys.)}$



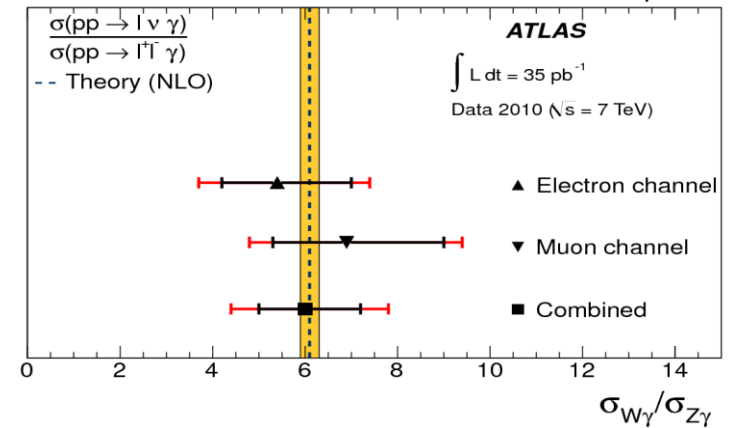
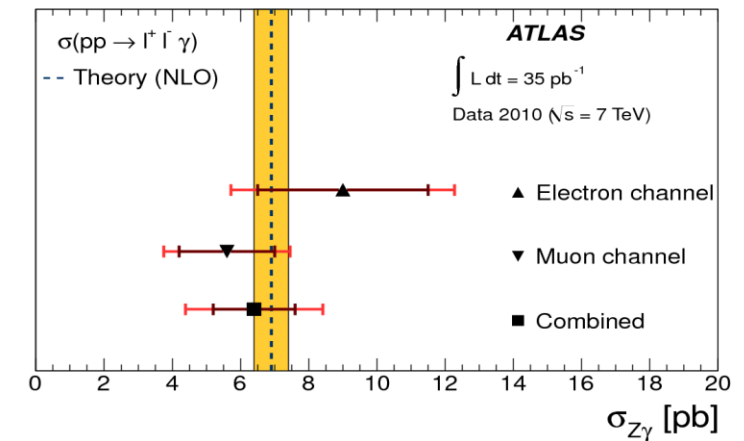
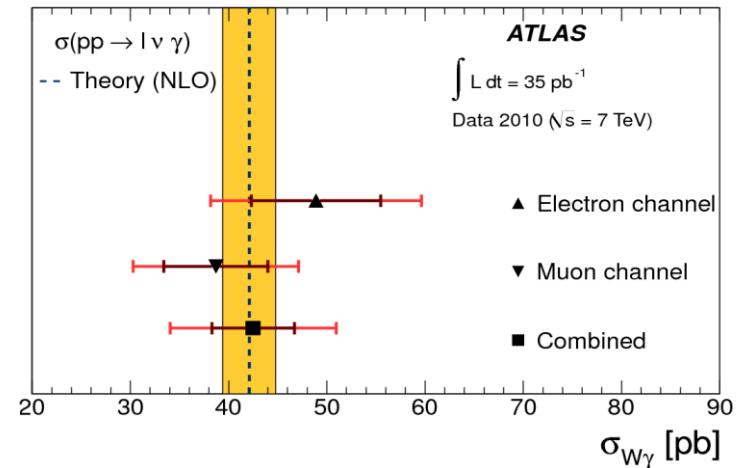
W_γ and Z_γ Production



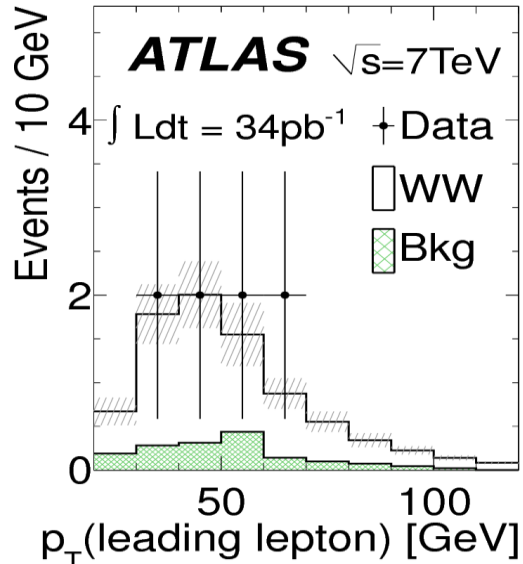
High p_T lepton plus photon
with $E_T > 15$ GeV
 $\Delta R(l, \gamma) > 0.7$



	Experimental measurement SM prediction	
	$\sigma^{\text{hd}}[\text{pb}]$	$\sigma^{\text{hd}}[\text{pb}]$
$pp \rightarrow e^\pm \nu \gamma$	$5.4 \pm 0.7 \pm 0.9 \pm 0.2$	4.7 ± 0.3
$pp \rightarrow \mu^\pm \nu \gamma$	$4.4 \pm 0.6 \pm 0.7 \pm 0.2$	4.9 ± 0.3
$pp \rightarrow e^+ e^- \gamma$	$2.2 \pm 0.6 \pm 0.5 \pm 0.1$	1.7 ± 0.1
$pp \rightarrow \mu^+ \mu^- \gamma$	$1.4 \pm 0.3 \pm 0.3 \pm 0.1$	1.7 ± 0.1
	$\sigma[\text{pb}]$	$\sigma[\text{pb}]$
$pp \rightarrow e^\pm \nu \gamma$	$48.9 \pm 6.6 \pm 8.3 \pm 1.7$	42.1 ± 2.7
$pp \rightarrow \mu^\pm \nu \gamma$	$38.7 \pm 5.3 \pm 6.4 \pm 1.3$	42.1 ± 2.7
$pp \rightarrow l^\pm \nu \gamma$	$42.5 \pm 4.2 \pm 7.2 \pm 1.4$	42.1 ± 2.7
$pp \rightarrow e^+ e^- \gamma$	$9.0 \pm 2.5 \pm 2.1 \pm 0.3$	6.9 ± 0.5
$pp \rightarrow \mu^+ \mu^- \gamma$	$5.6 \pm 1.4 \pm 1.2 \pm 0.2$	6.9 ± 0.5
$pp \rightarrow l^+ l^- \gamma$	$6.4 \pm 1.2 \pm 1.6 \pm 0.2$	6.9 ± 0.5



WW Production



2 isolated leptons (e or μ)

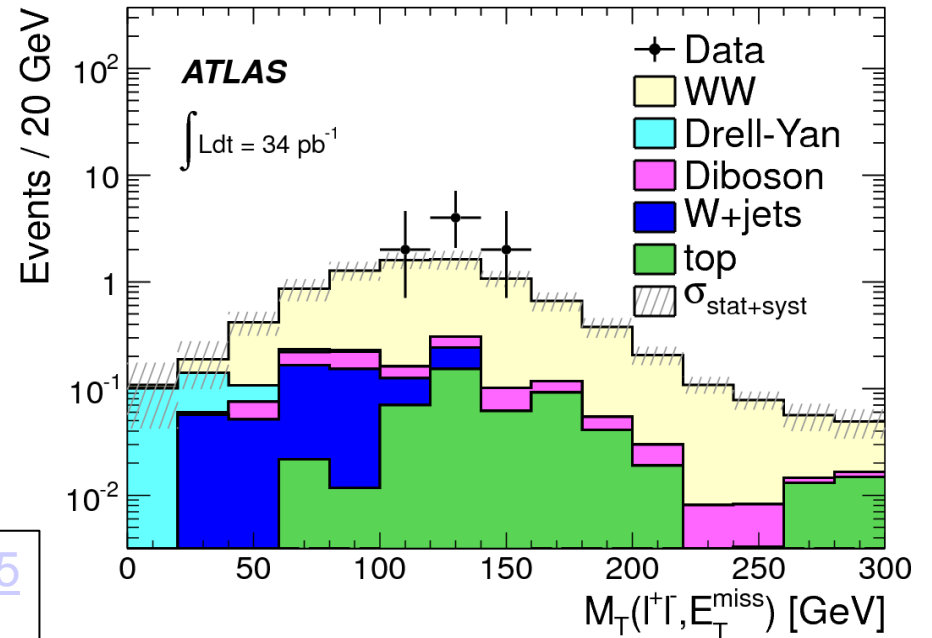
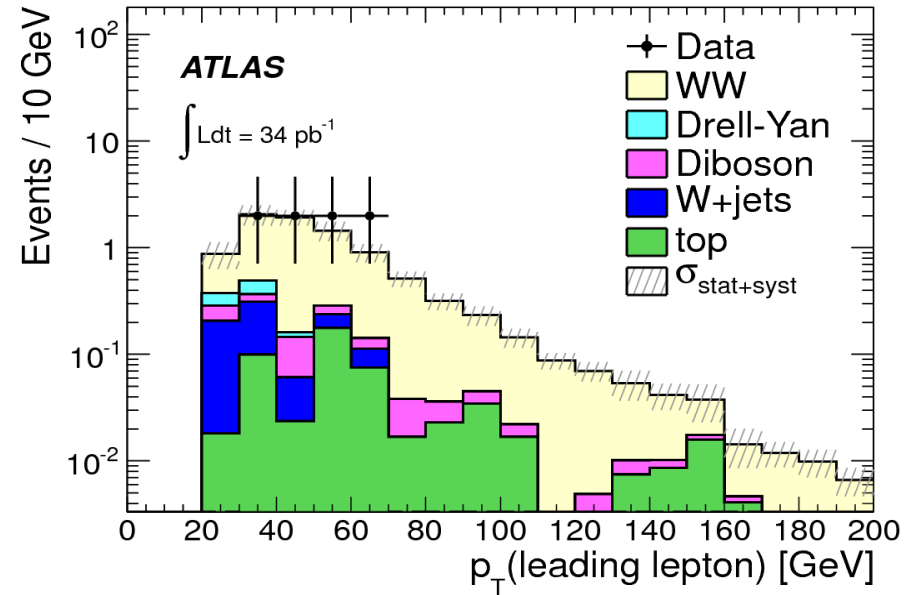
Observed: 8 events

Expected: 1.7 ± 0.6

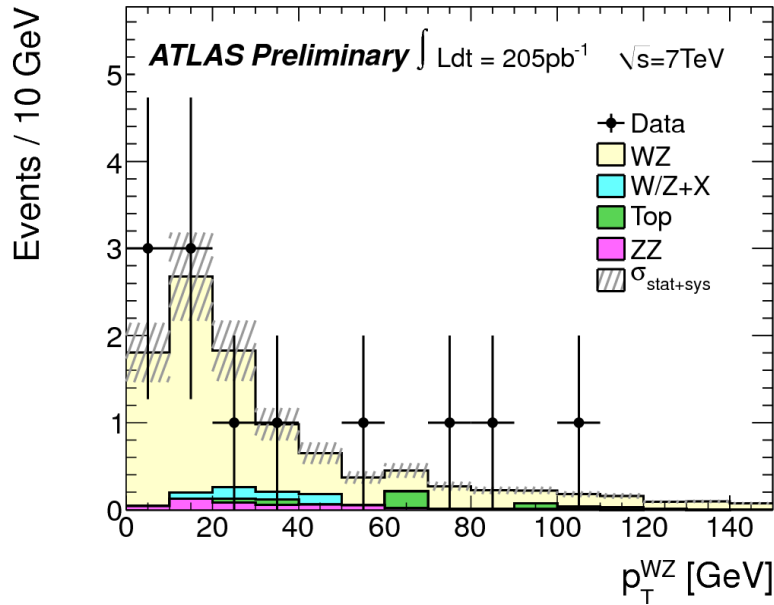
$$\sigma = 41^{+20}_{-16}(\text{stat.}) \pm 5(\text{syst.}) \pm 1(\text{lumi.}) \text{ pb}$$

SM: $44 \pm 4 \text{ pb}$

<http://arxiv.org/abs/1104.5225>
 Submitted to PRL



WZ Production

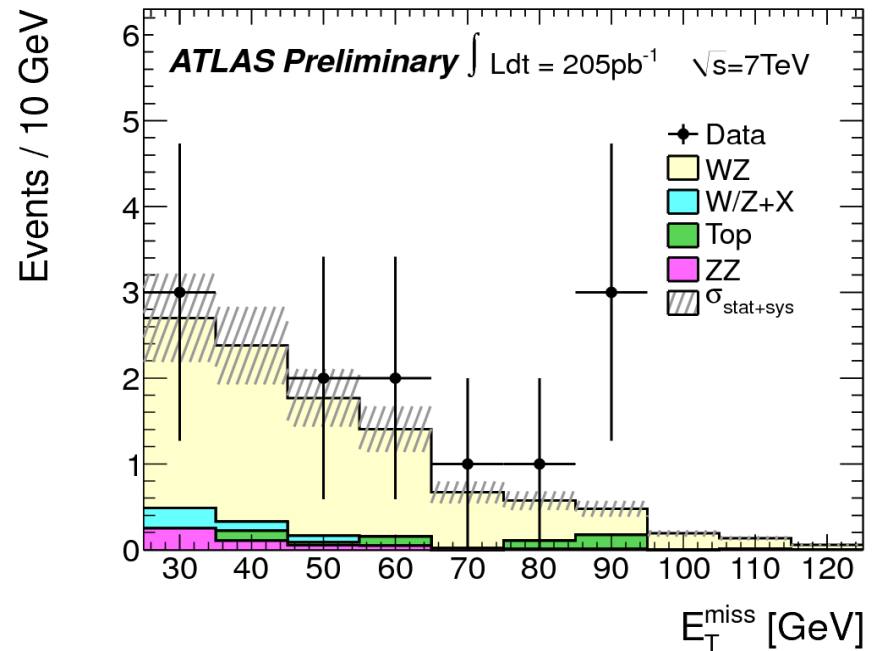


Obs: 12 events

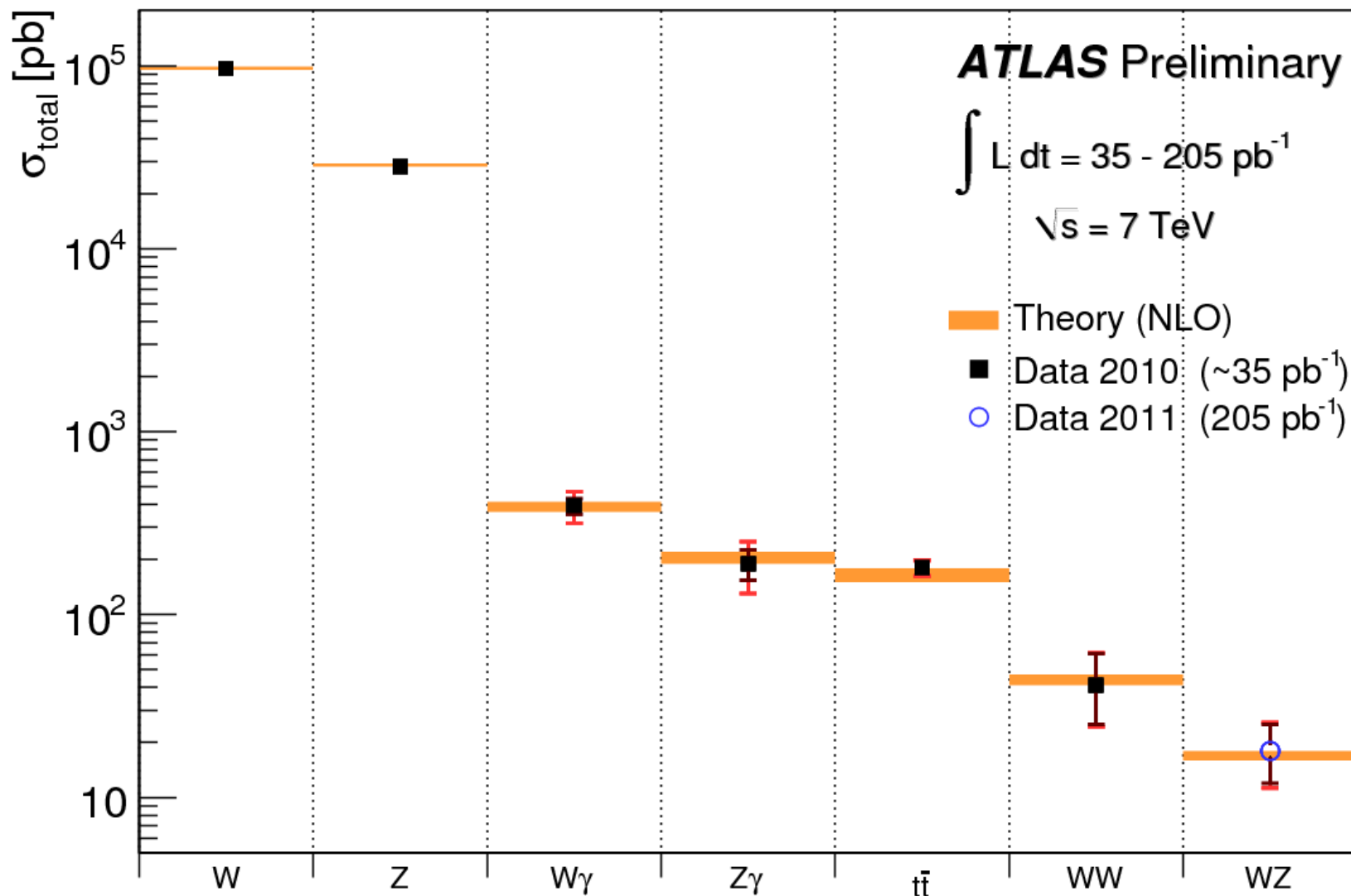
Background exp: 2 events

$$\sigma_{WZ}^{\text{tot}} = 18_{-6}^{+7}(\text{stat}) \pm 3(\text{syst}) \pm 1(\text{lumi}) \text{ pb}$$

$$\text{SM: } 16.9_{-0.8}^{+1.2} \text{ pb}$$



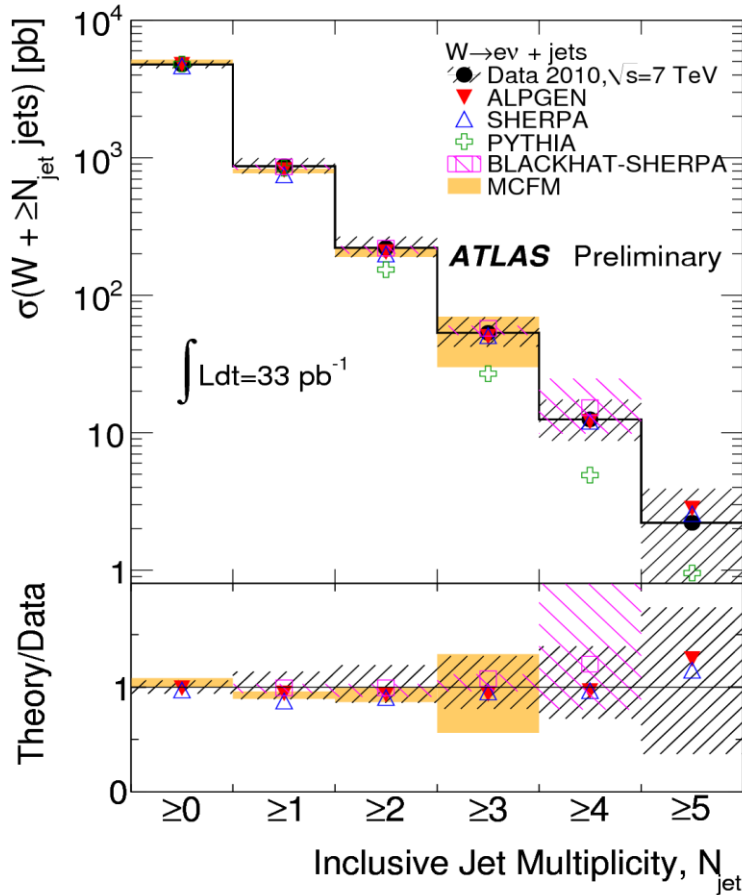
Standard Model Cross Section Measurements



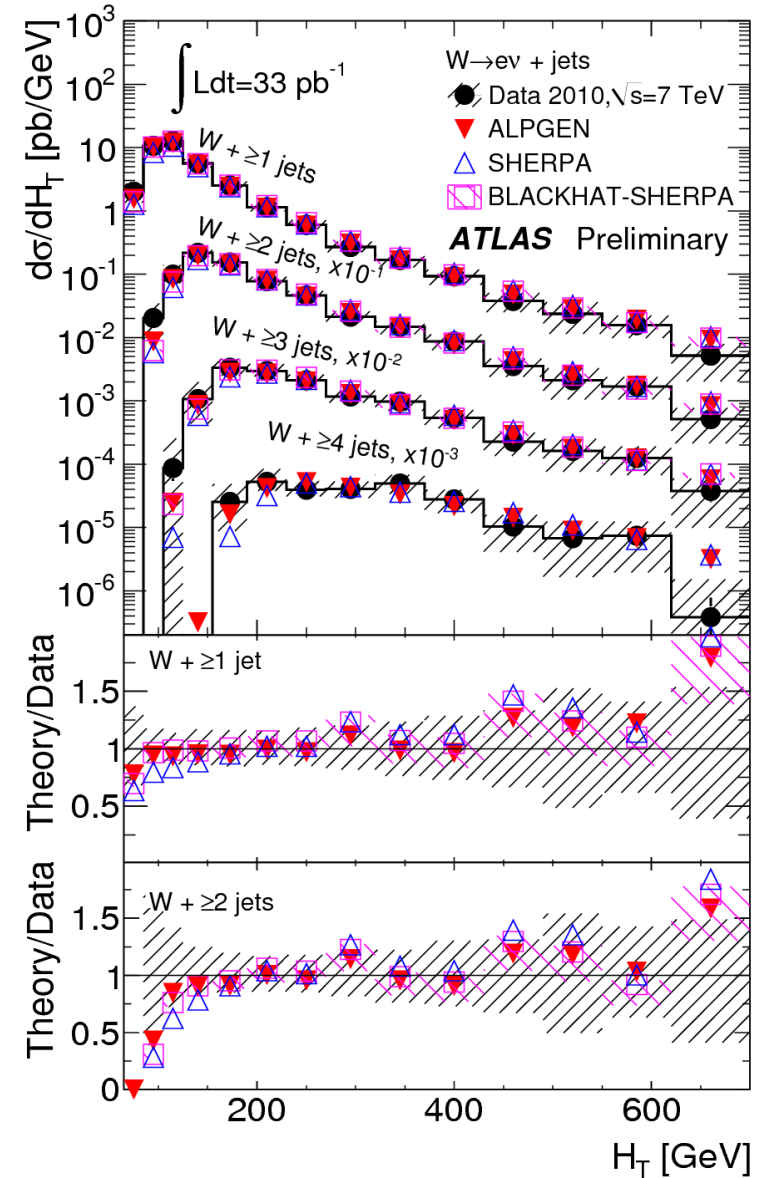
See also...

L. Dell'Asta: *Electroweak Results with the 2010
ATLAS Data*
Tuesday, 17:40h

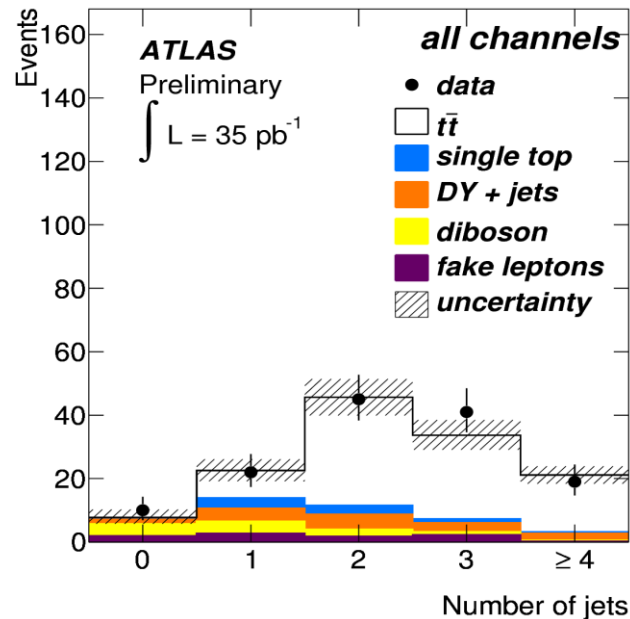
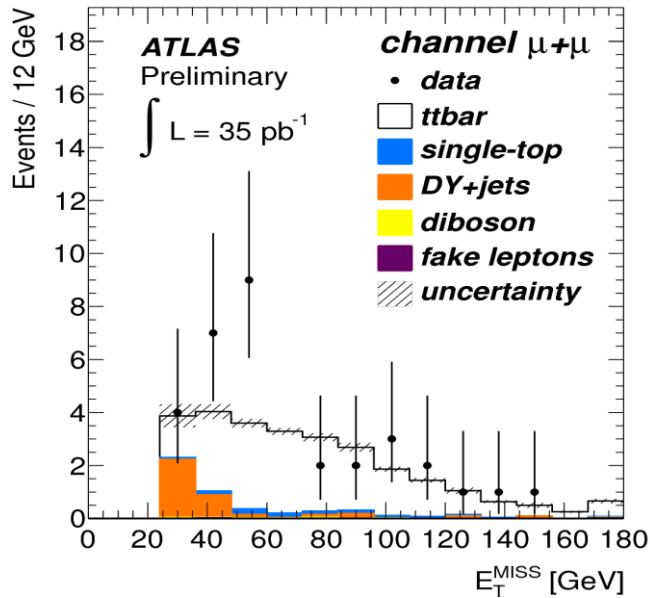
W+jets Measurement



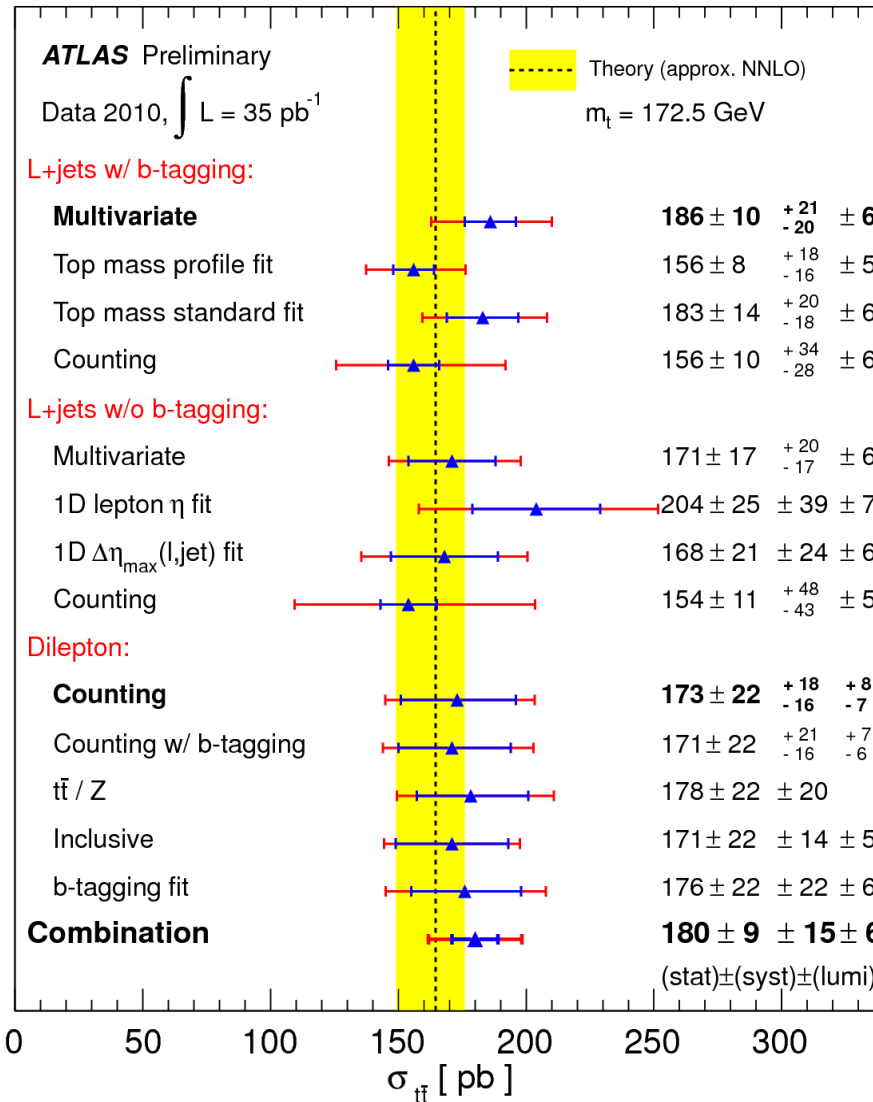
One of the most important background for many searches.
 Now reaching up to $N_{\text{jet}} \geq 5$



Top Pair Production Cross Section



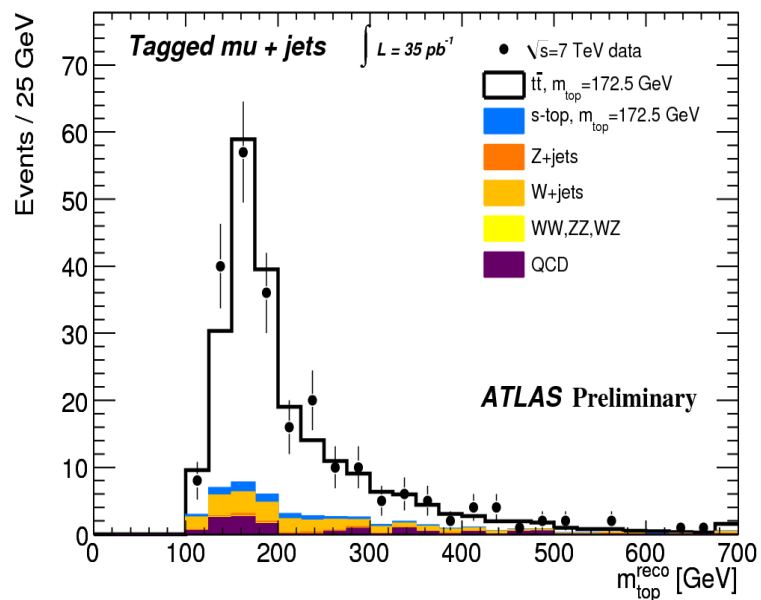
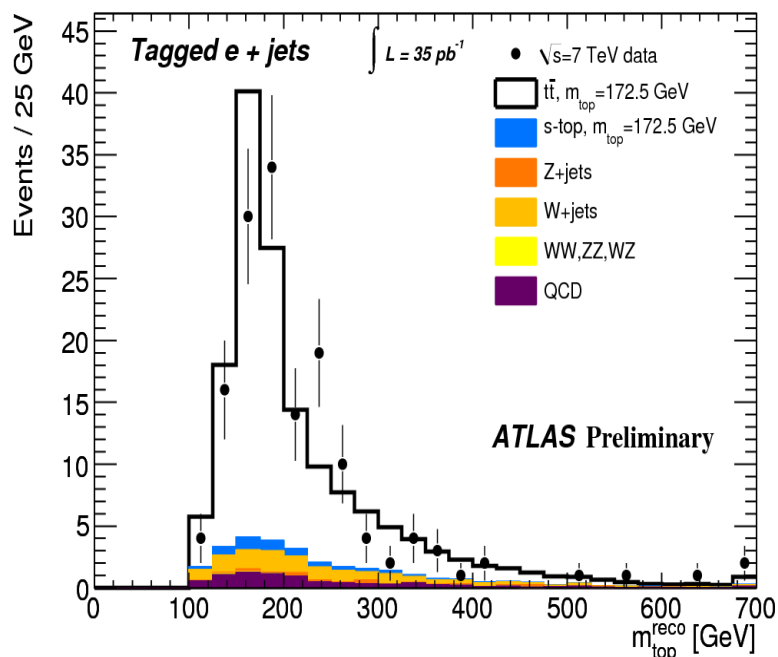
In all channels: lepton + jet, di-lepton, with and Without b-tagging.



Also all-hadronic search
 : 6 jets, ≥ 2 b jets

Upper limit:
 261 pb @ 95 CL

Top Mass

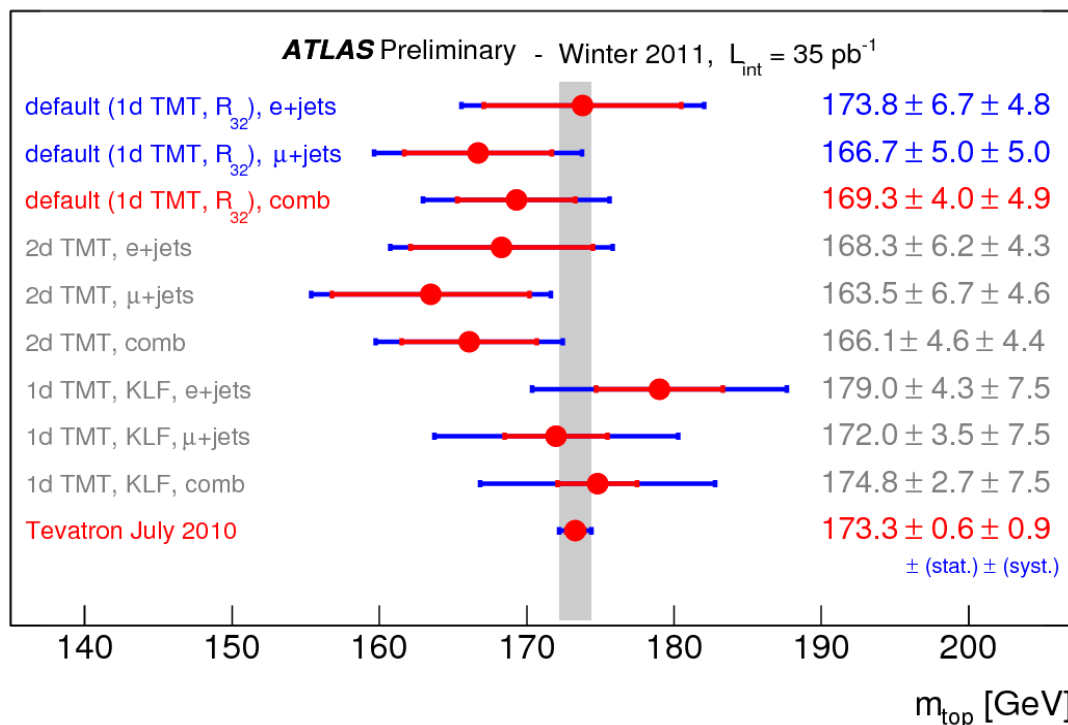


Template method in lepton + jets channel.

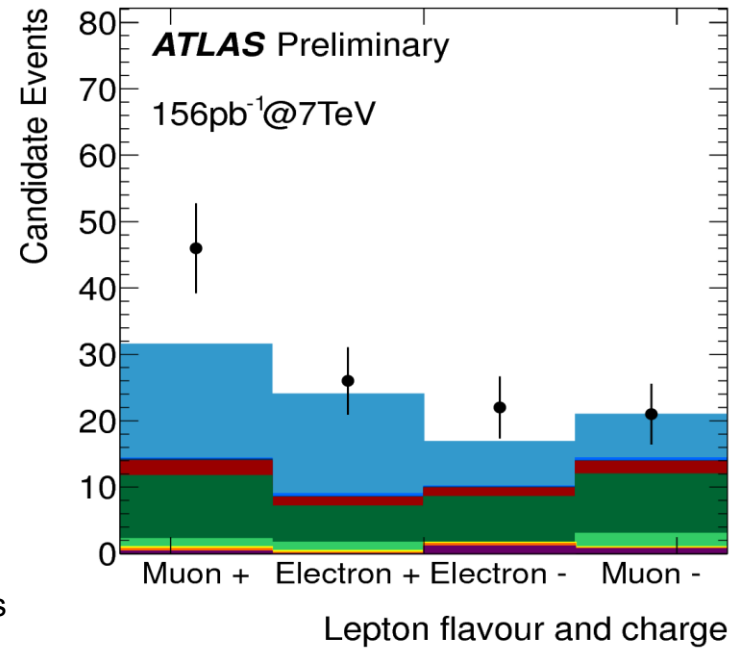
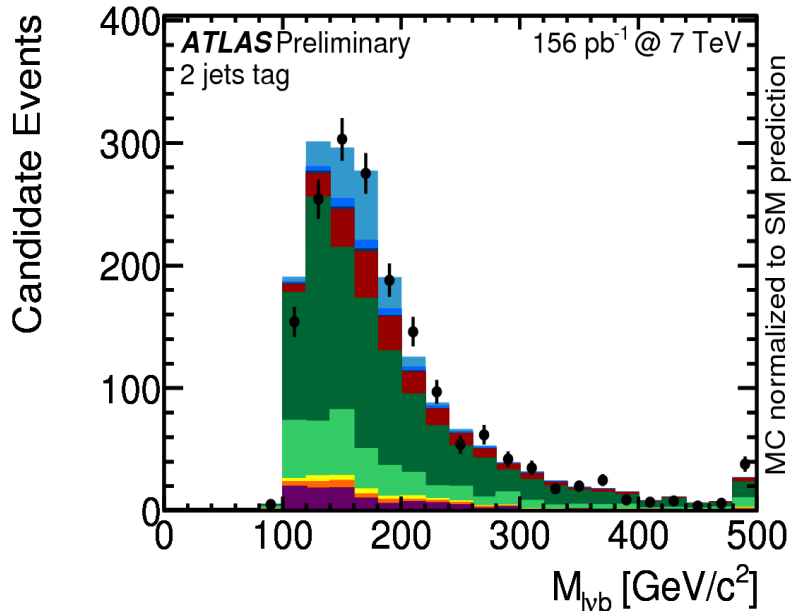
$$M_{\text{top}} = 169.3 \pm 4.0 \pm 4.9 \text{ GeV}$$

Plus two additional variations on the template Method.

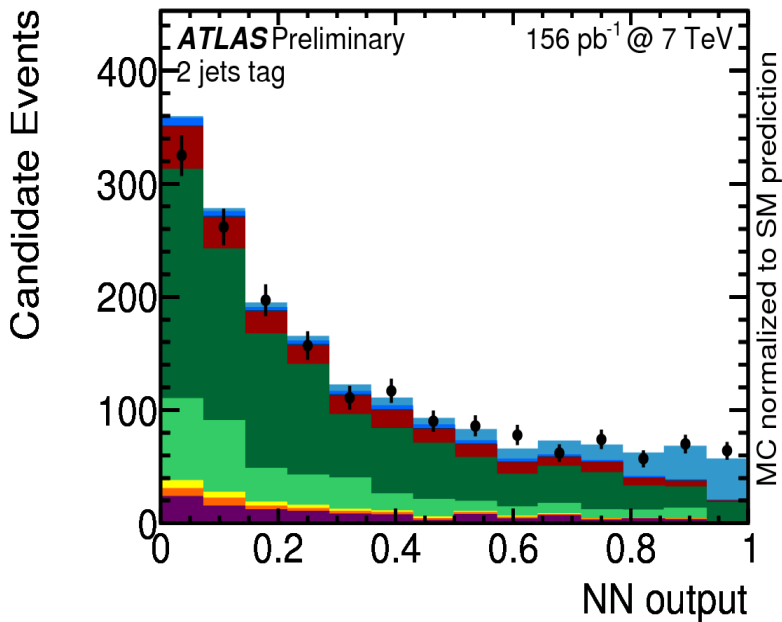
Also extracted from cross section measurement:
 $M_{\text{top}} = 166.4^{+7.8}_{-7.3} \text{ GeV}$



Single Top Production



= 1 lepton, E_{T}^{miss}
= 2 jets, = 1 b jet

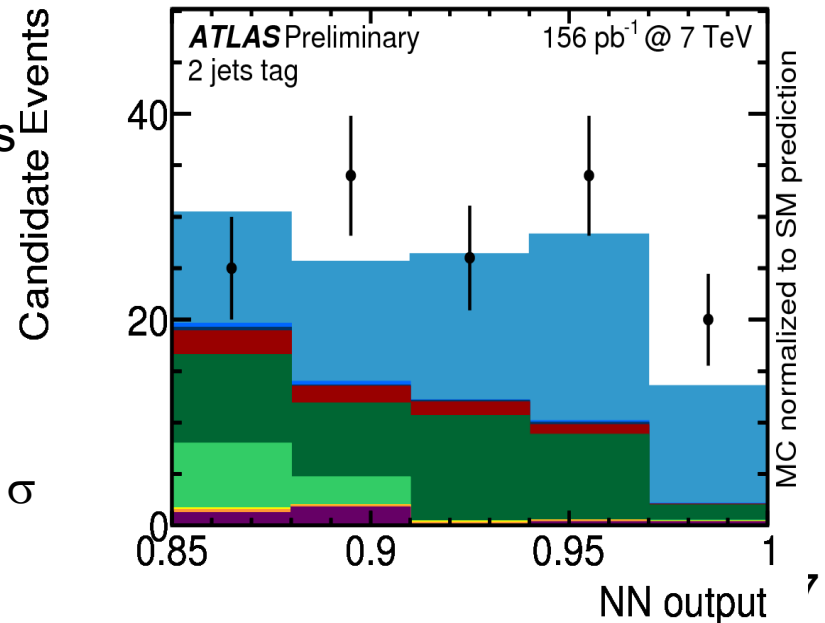


Both cut-based
And NN analysis

NN:

$$\sigma_t = 76^{+41}_{-21} \text{ pb}$$

Significance: 6.2σ

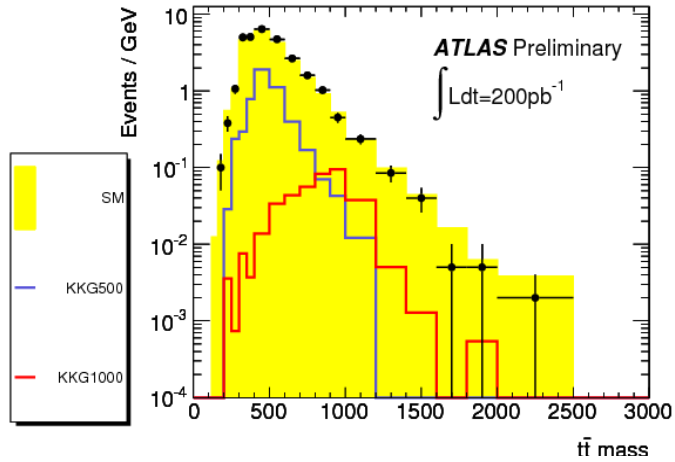


See also...

M. Barisonzi: *QCD and Top Physics Results with
the 2010 ATLAS Data*
Friday 14:40h

Searches for Higgs and other new Physics

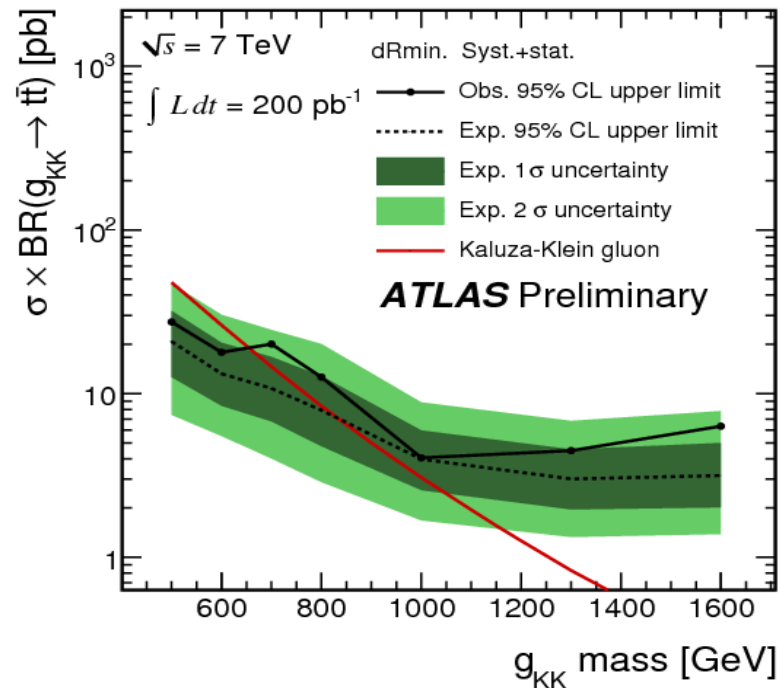
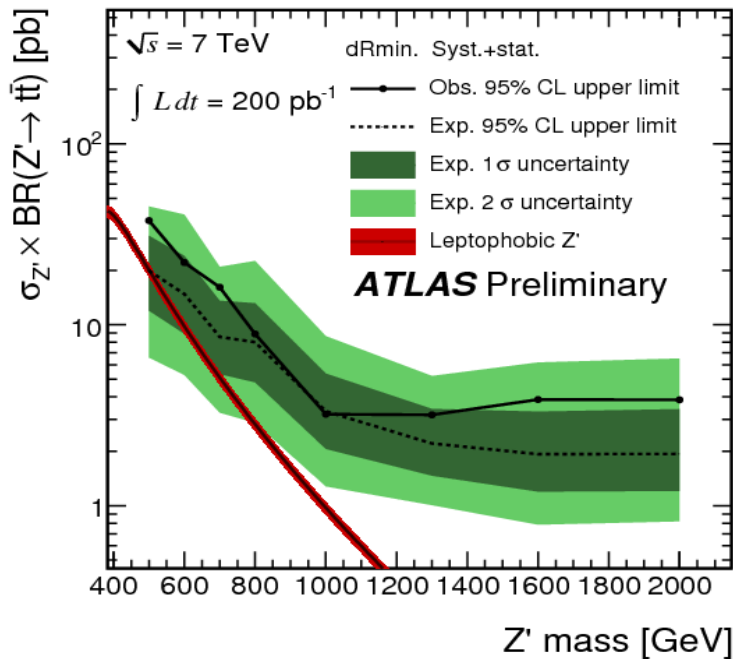
Resonant Top Pair Production



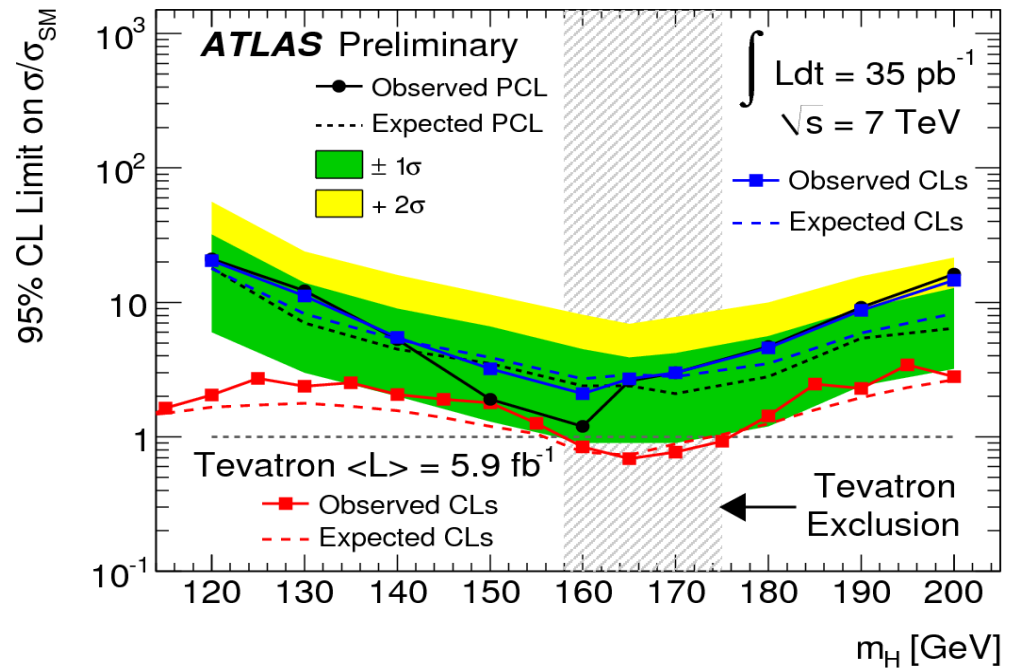
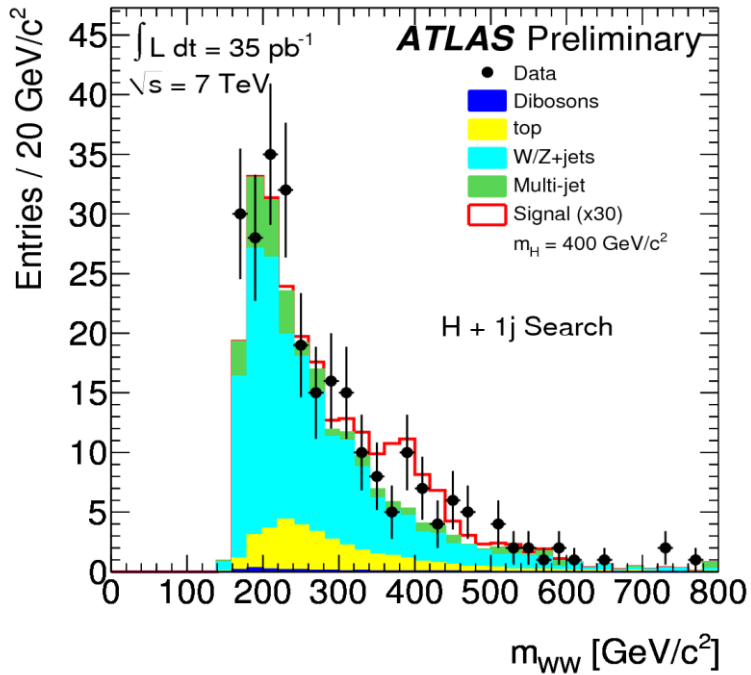
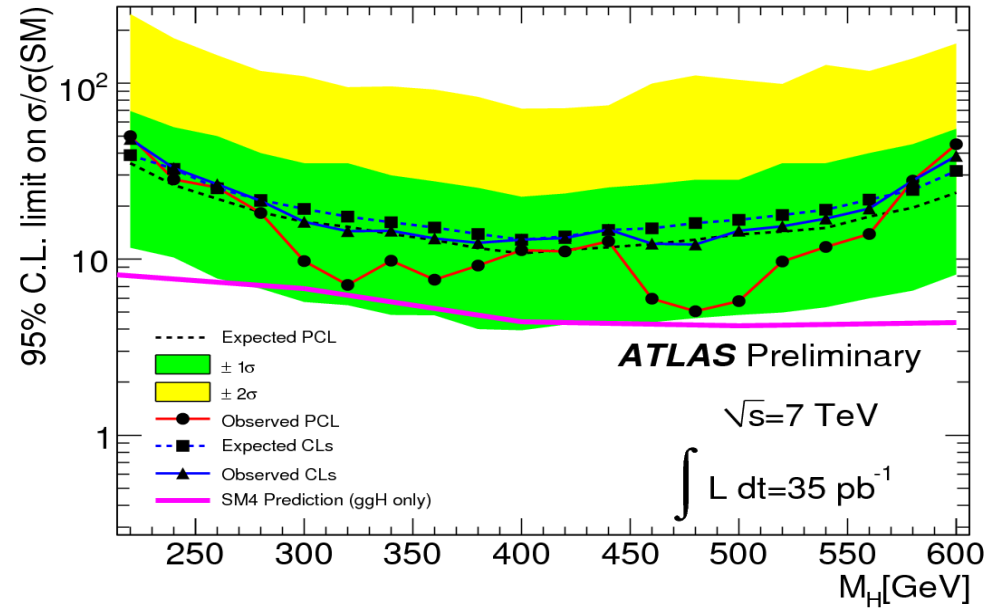
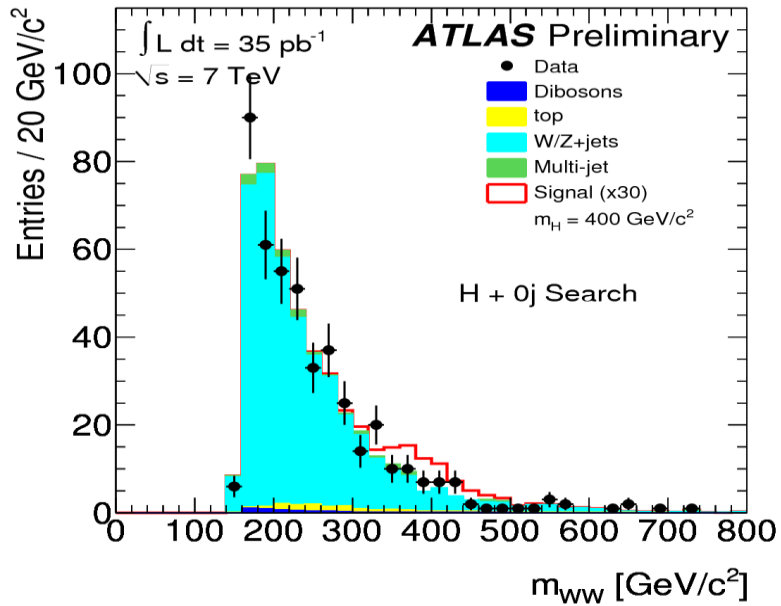
Search $t\bar{t}$ resonances in lepton + jets channel.

Limits on wide and narrow resonances.

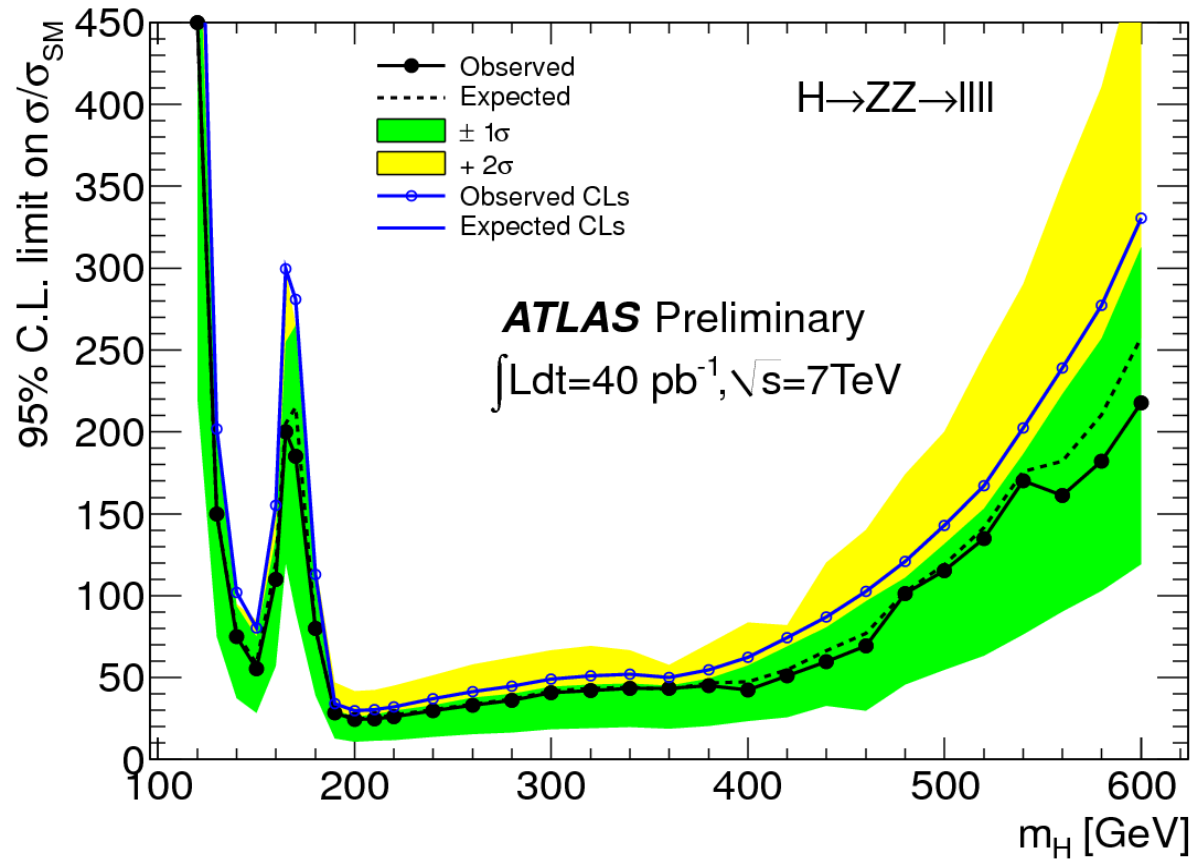
Z' : 38pb – 3.2pb for $M_{Z'} = 500$ to 1300 GeV
 KK gluon: exclude $M < 650$ GeV @ 95 CL



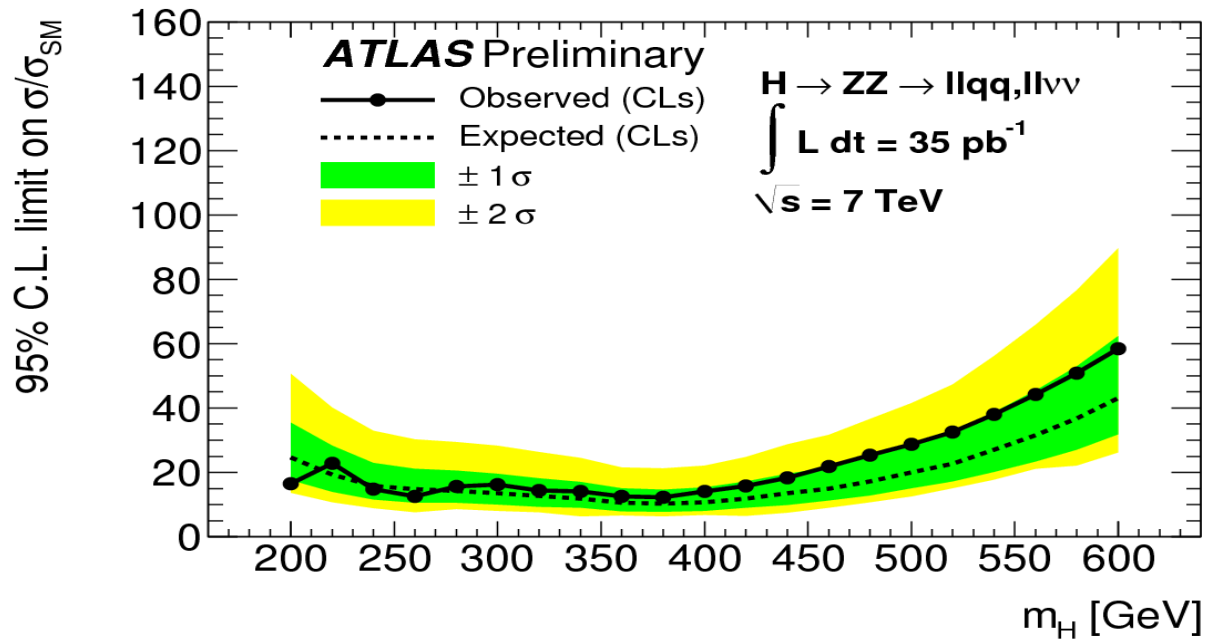
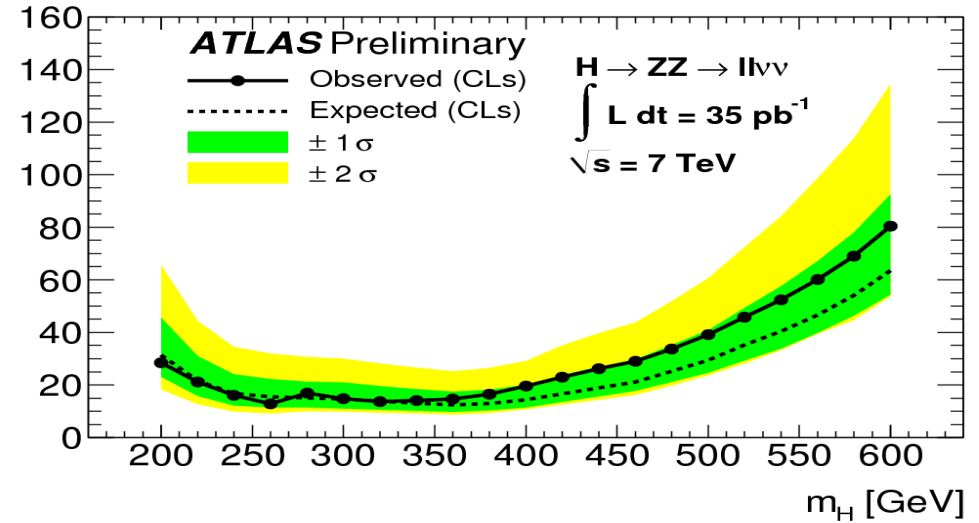
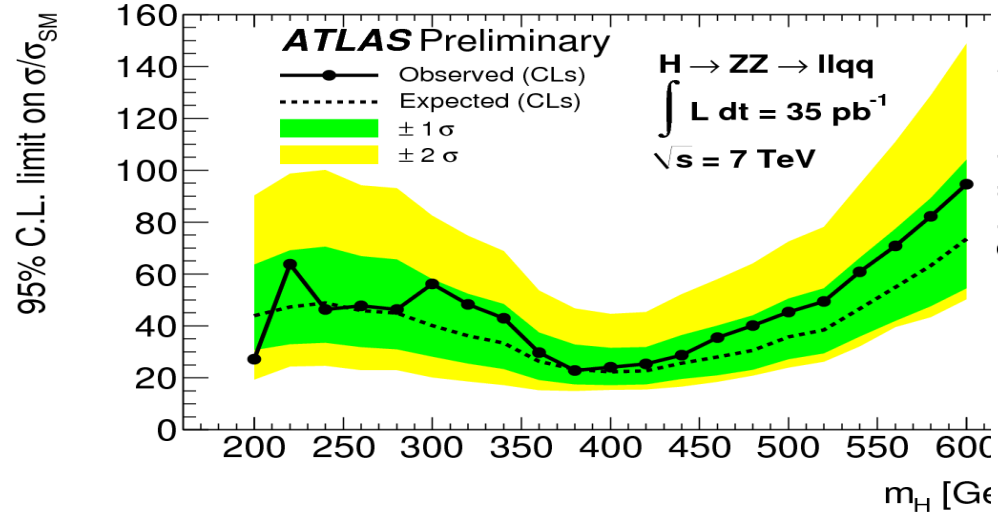
$H \rightarrow WW \rightarrow l\nu qq, l\nu l\nu$

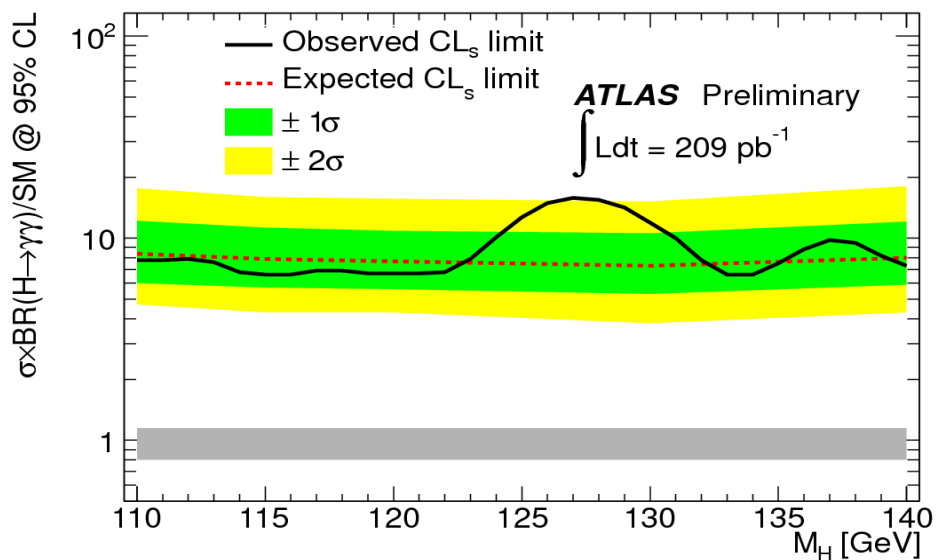
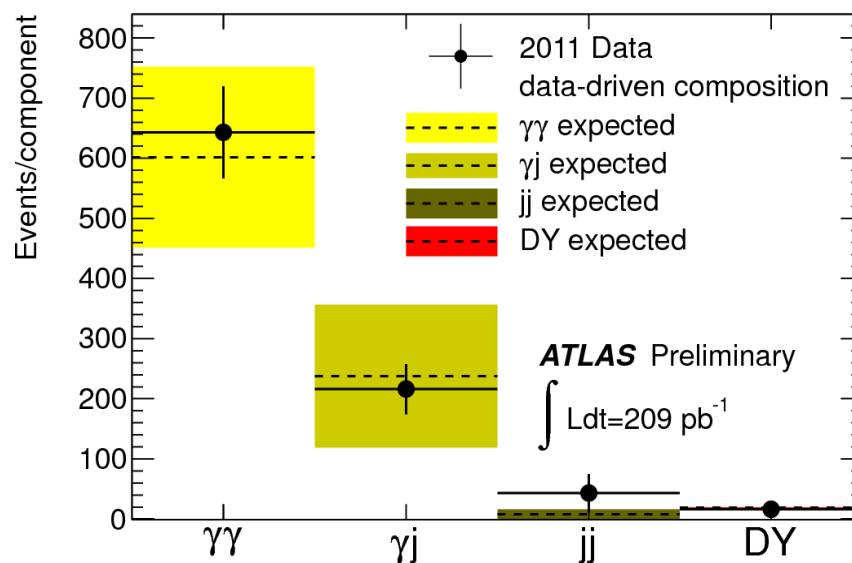
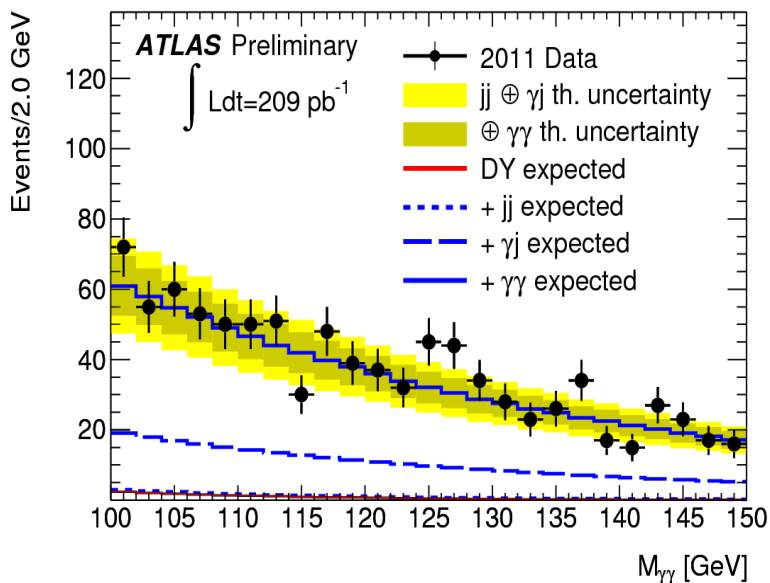


$H \rightarrow ZZ \rightarrow 4l$



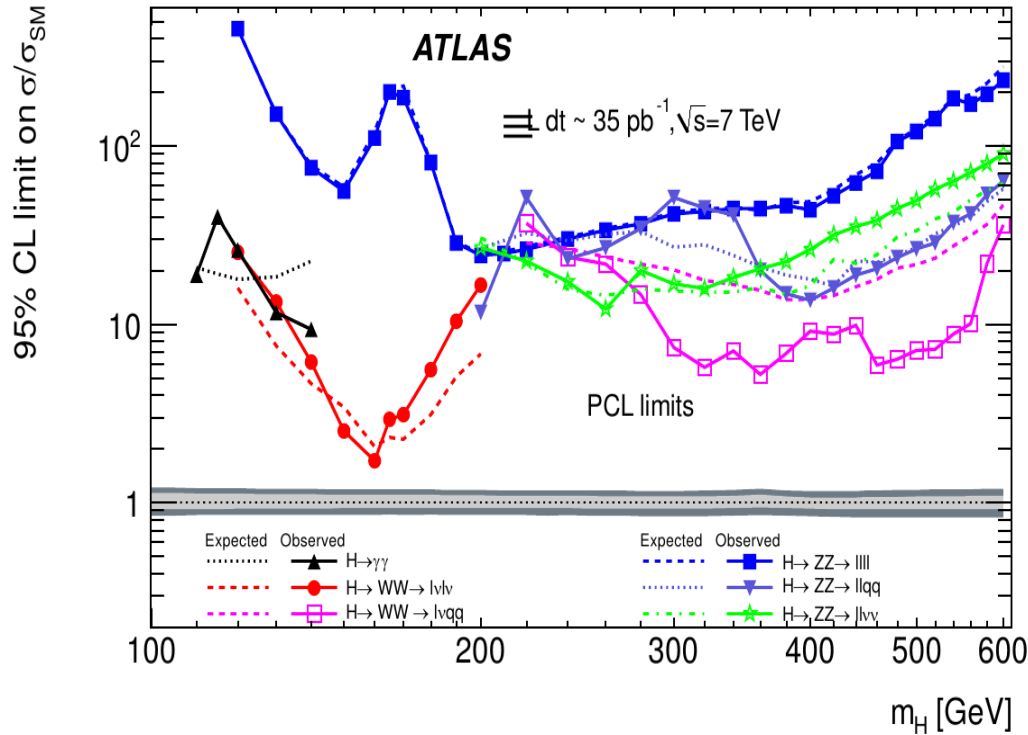
$H \rightarrow ZZ \rightarrow ll\nu\nu, llqq$



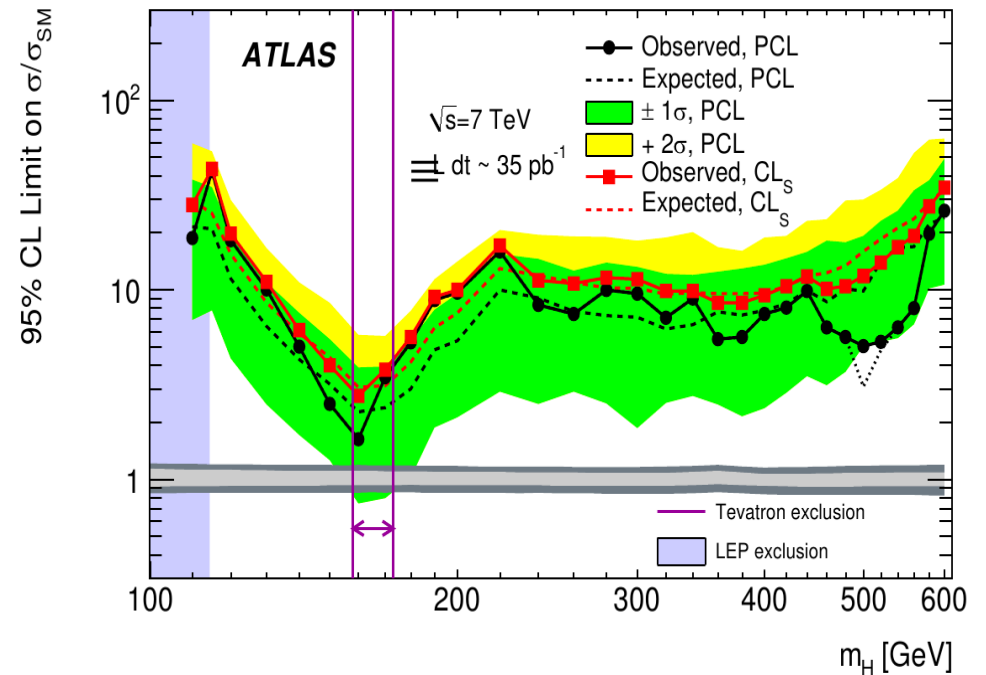


Higgs boson mass	110 (GeV)	115 (GeV)	120 (GeV)	130 (GeV)	140 (GeV)
Expected Signal	$3.5 \pm 0.4^{+0.7}_{-0.5}$	$3.6 \pm 0.4^{+0.7}_{-0.5}$	$3.6 \pm 0.4^{+0.7}_{-0.5}$	$3.2 \pm 0.4^{+0.7}_{-0.5}$	$2.5 \pm 0.3^{+0.5}_{-0.4}$
$1 - CL_b$	55%	65%	65%	10%	52%
Expected σ_{95}/σ_{SM}	6.9	6.5	6.4	6.0	6.9
Observed σ_{95}/σ_{SM}	5.7	4.2	4.6	11.7	4.9

Higgs Combination



All channels discussed so far,
Luminosity $\sim 35 \text{ pb}^{-1}$



<http://arxiv.org/pdf/1106.2748v2>

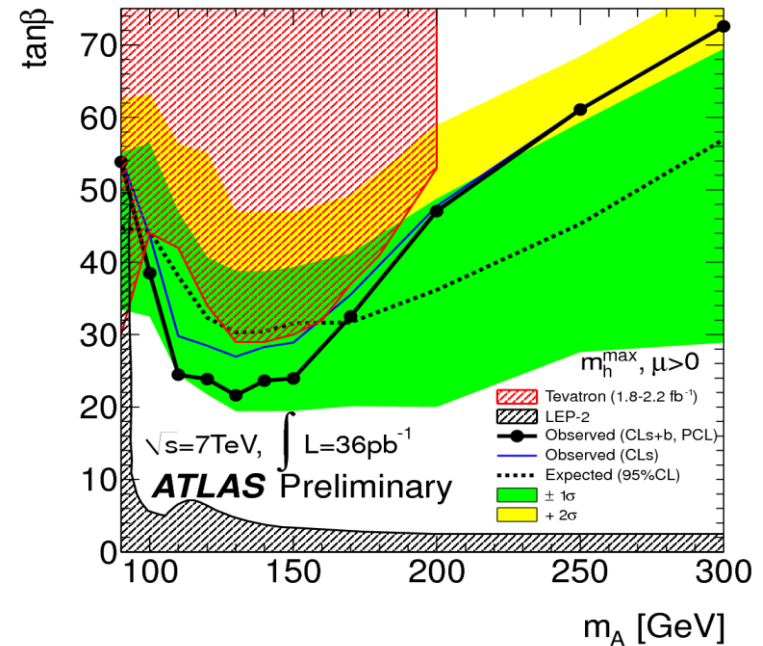
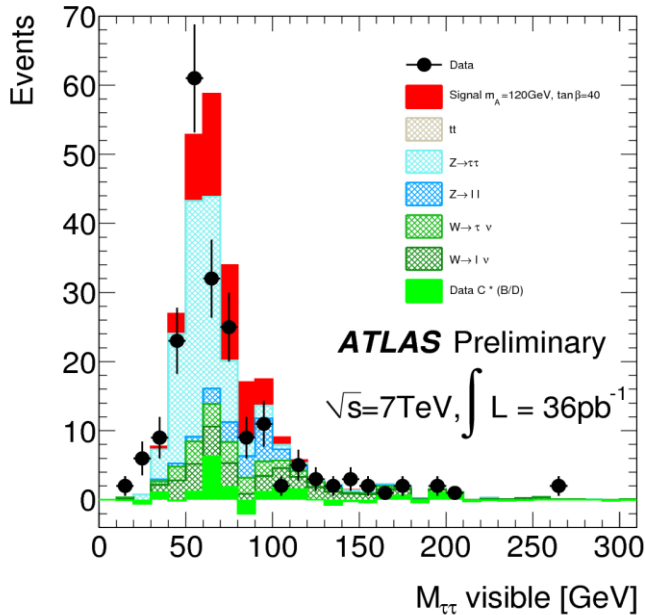
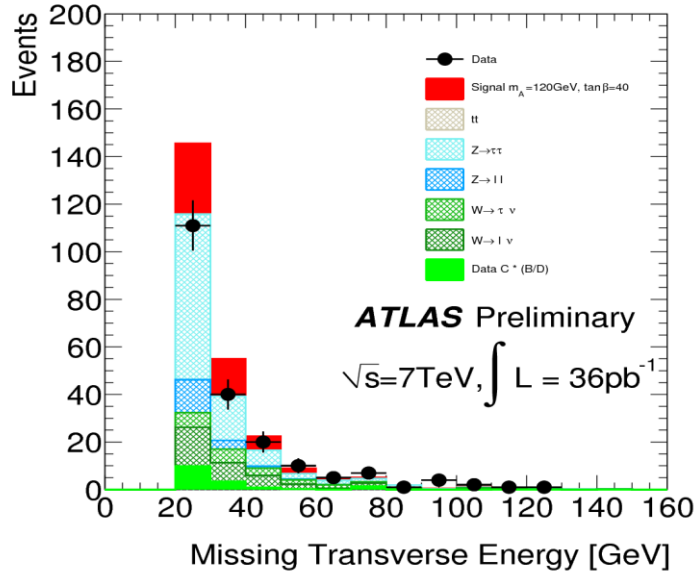
Submitted to EJP

MSSM Higgs

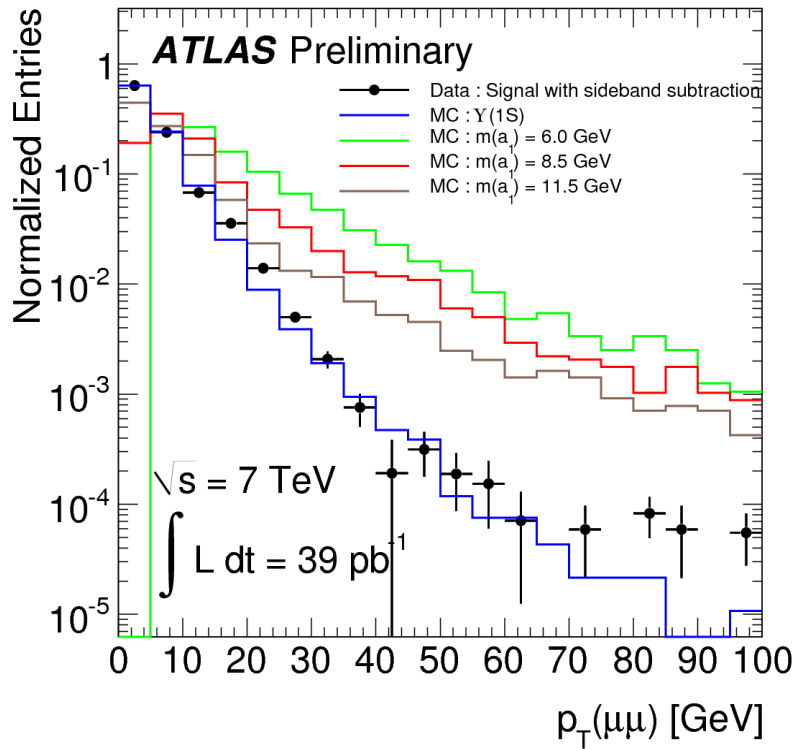
Search for neutral Higgs boson A, H, h in MSSM.

$H \rightarrow \tau\tau$, 1 leptonic + 1 hadronic decay.

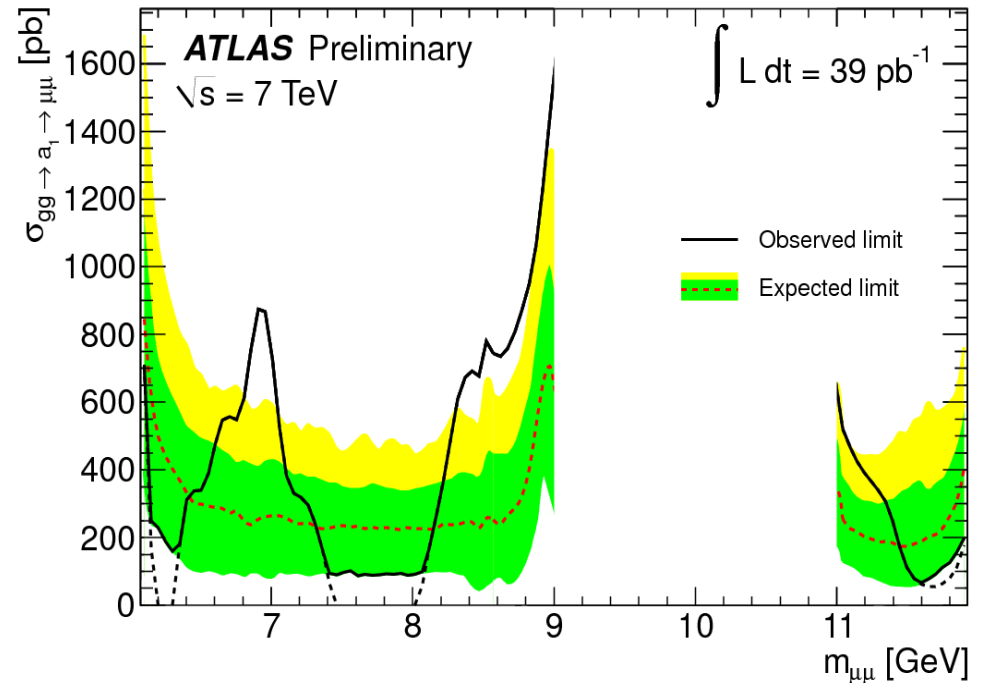
Obs: 206 events, expected: 195 ± 33



Light CP-Odd Higgs $a_1 \rightarrow \mu\mu$



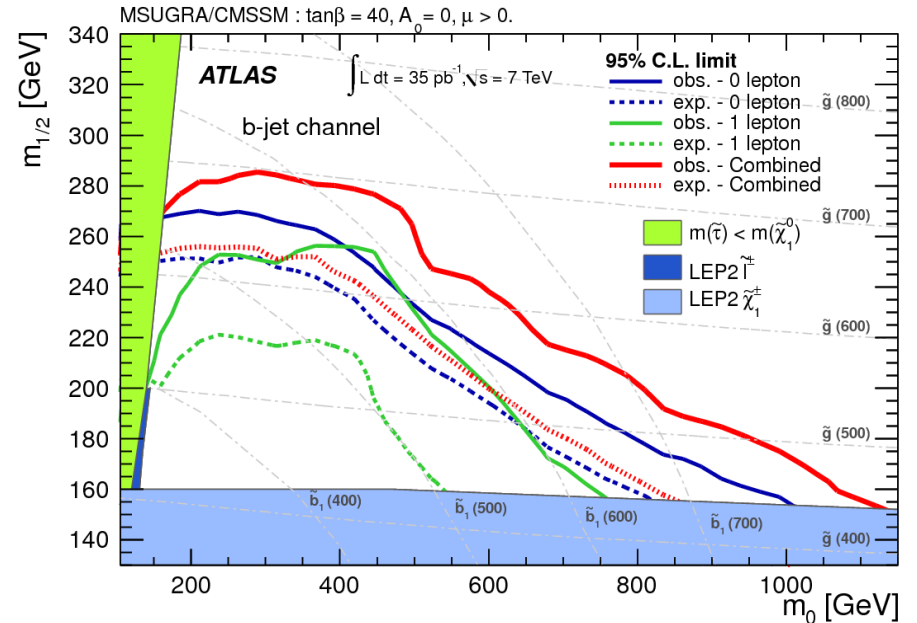
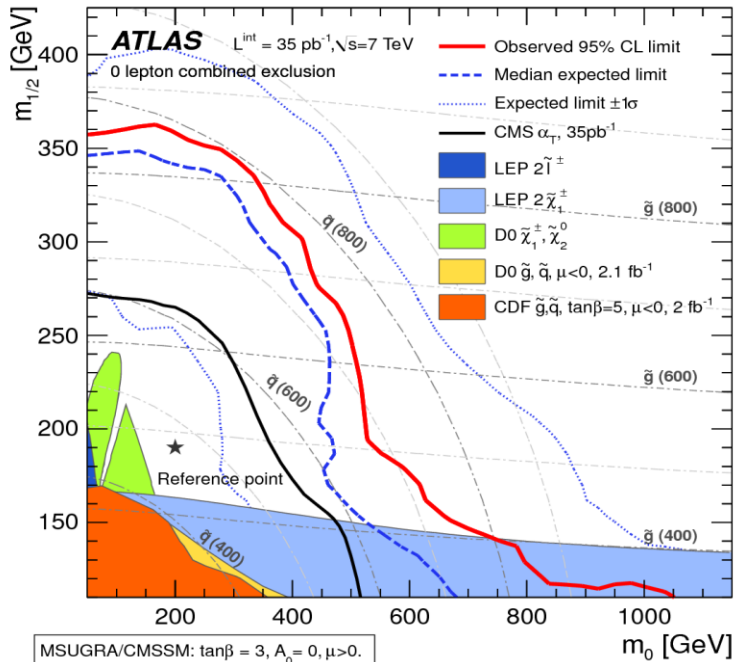
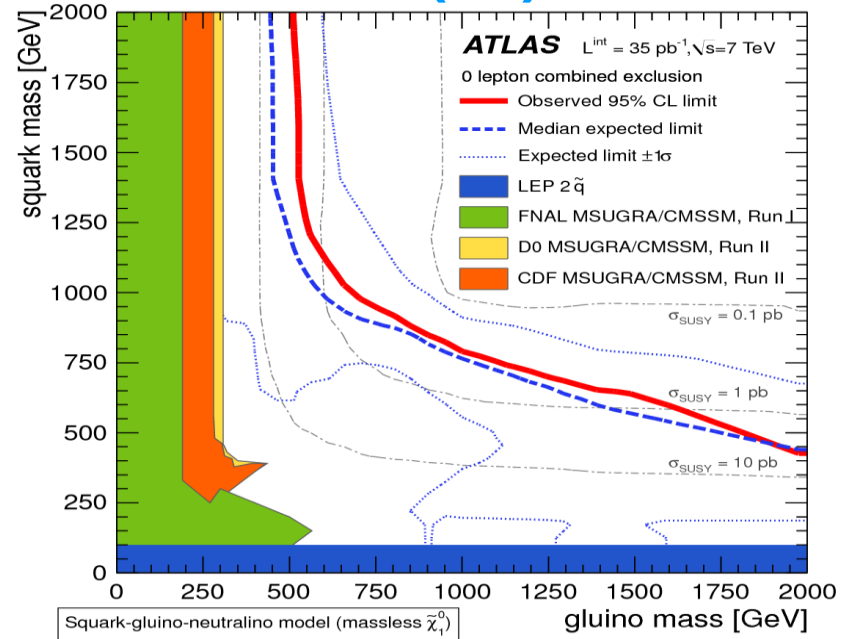
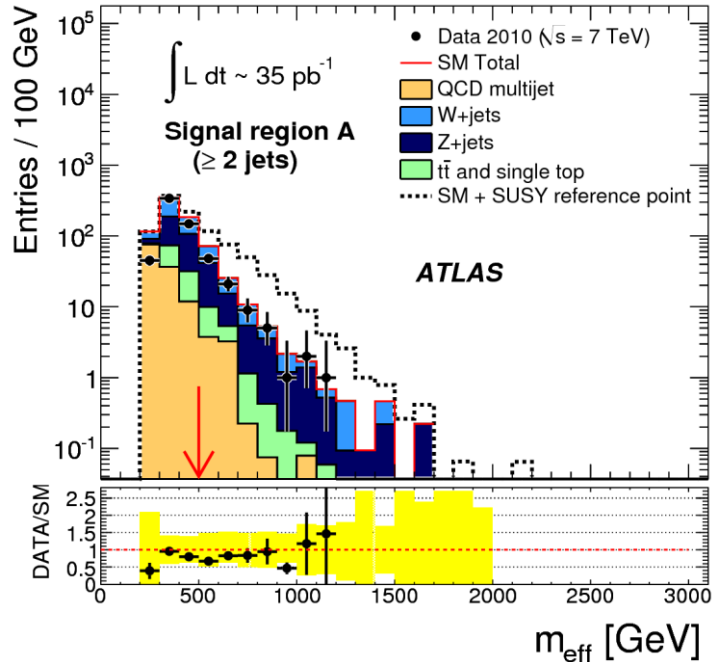
Light higgs in NMSSM
 Could have extremely low mass ~few GeV



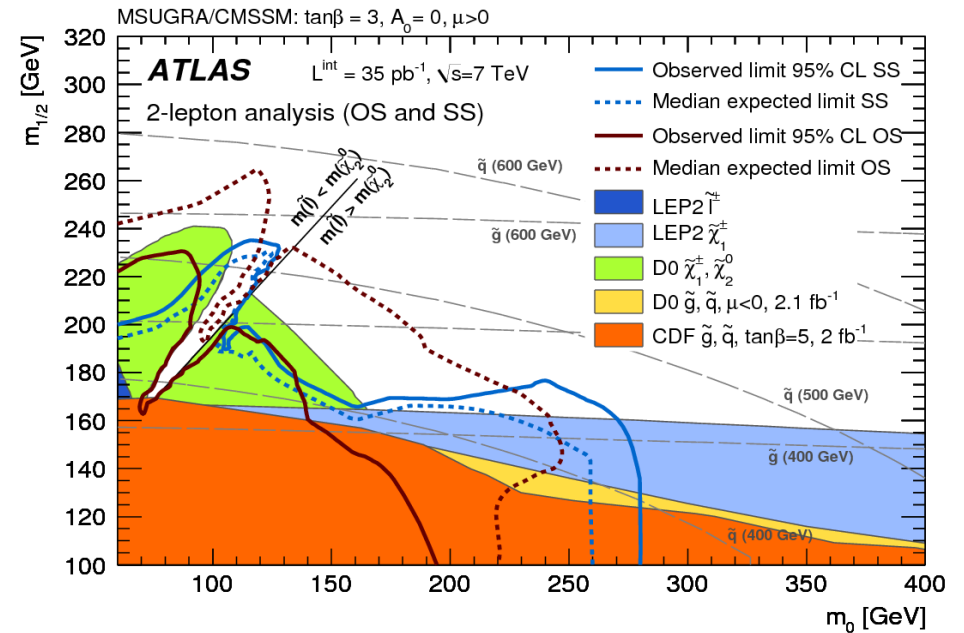
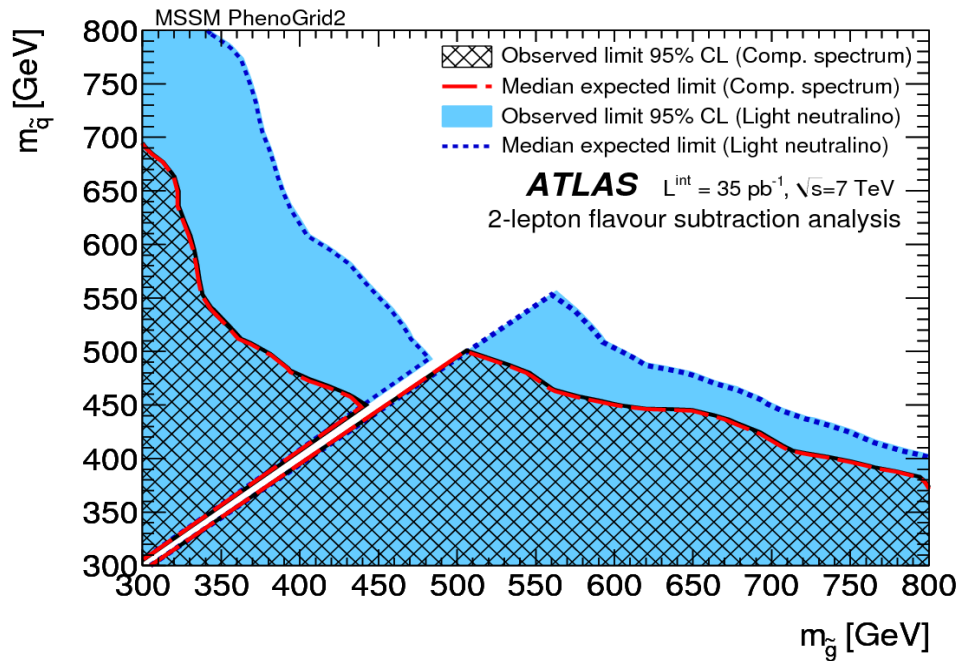
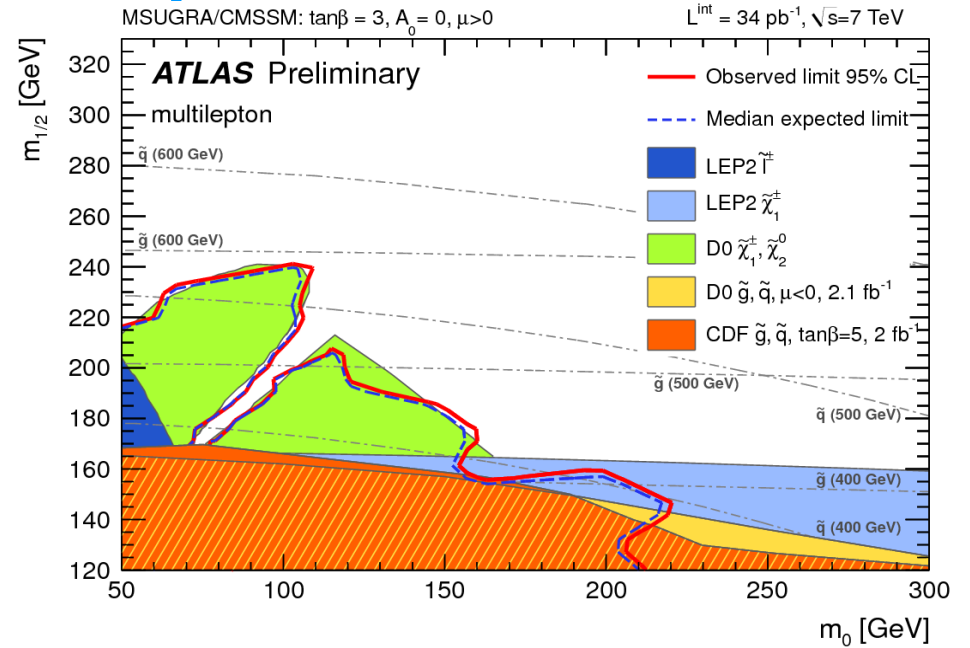
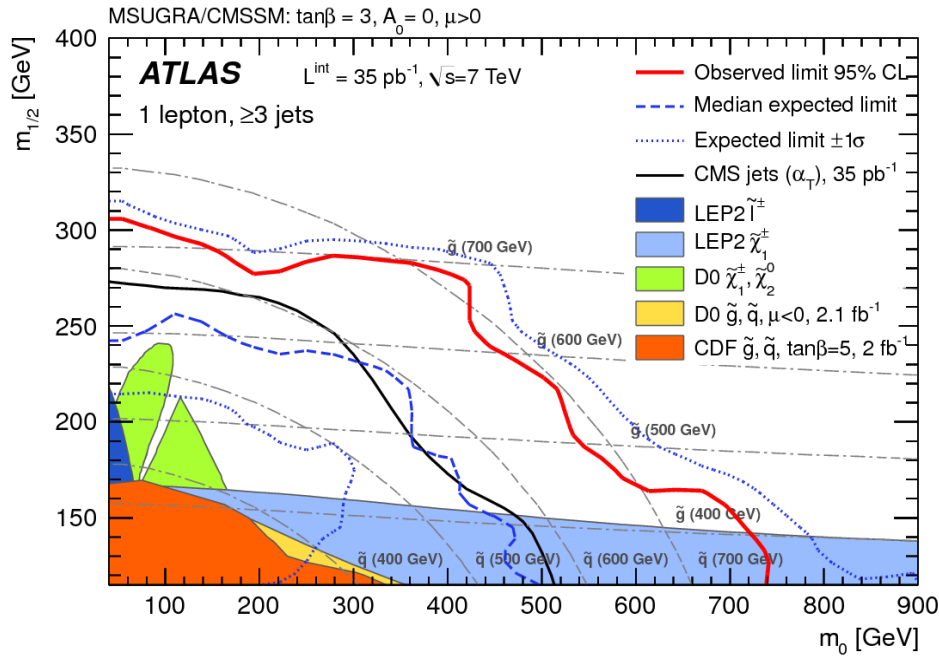
See also...

T. Yamamura: *Early Higgs Searches with the ATLAS Data*
Monday, 16:00h

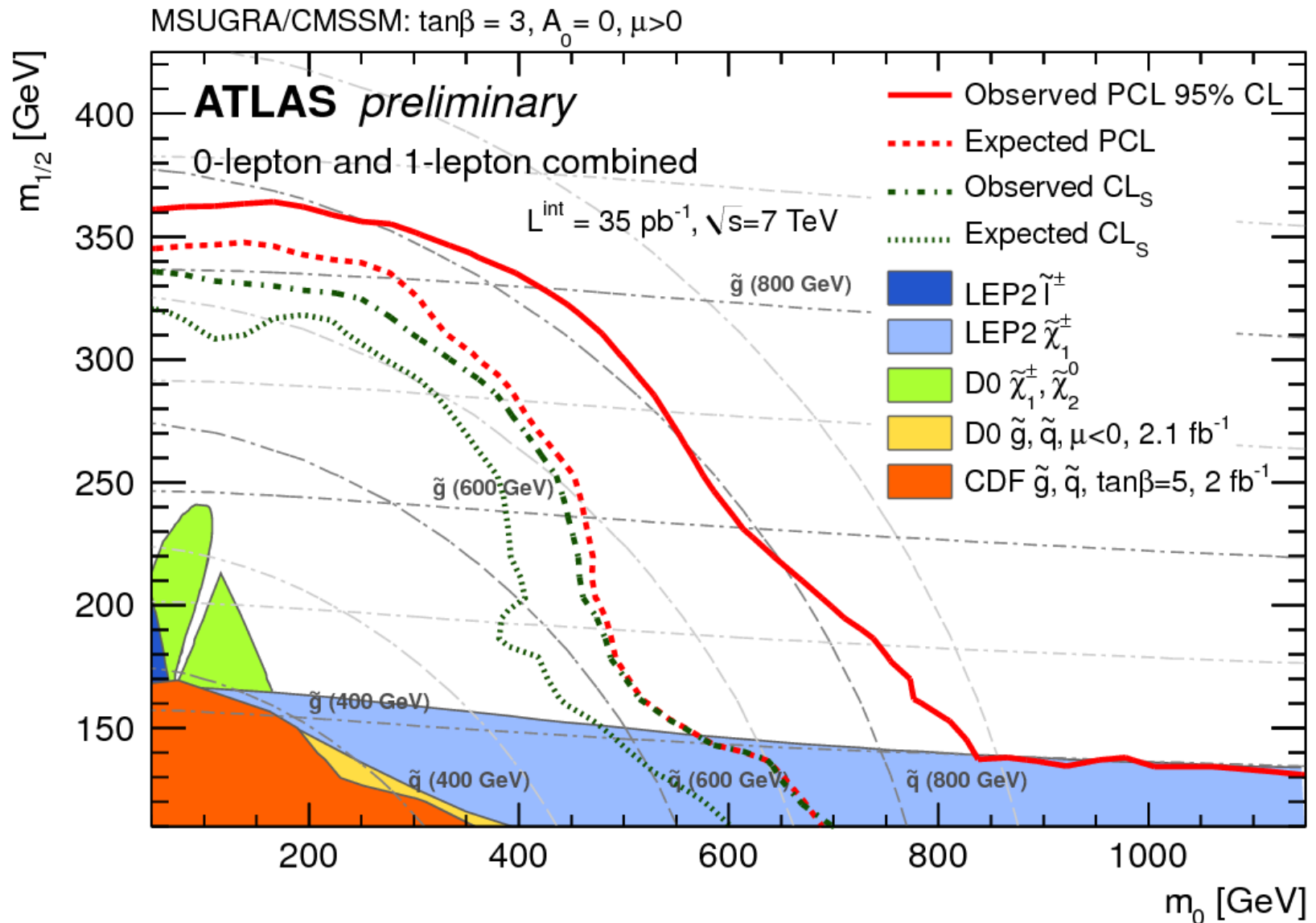
SUSY: Missing ET and (b)Jets



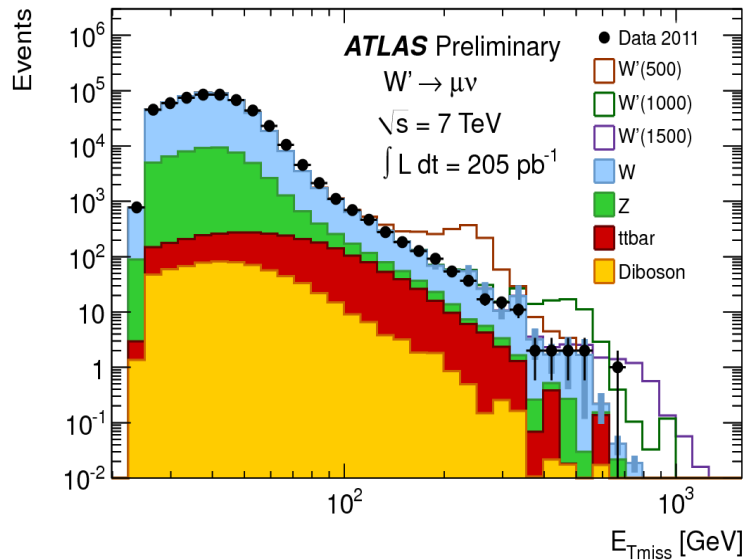
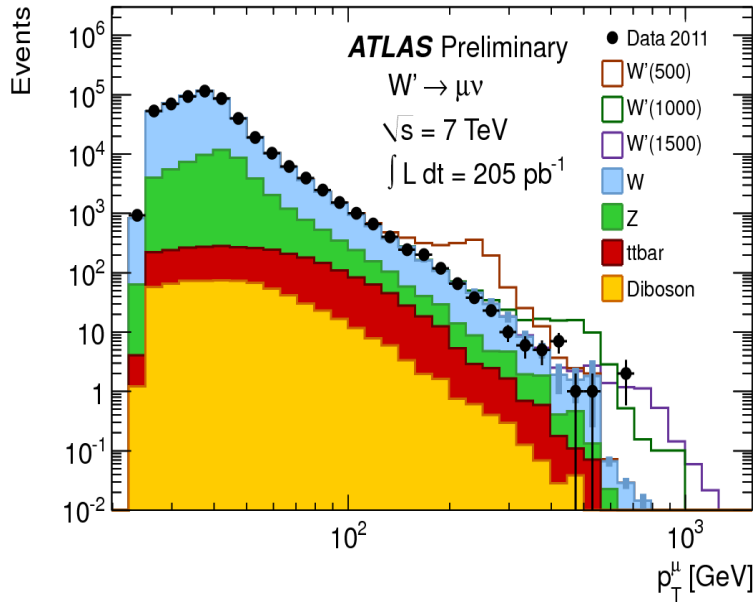
SUSY with leptons



SUSY Combined Exclusion

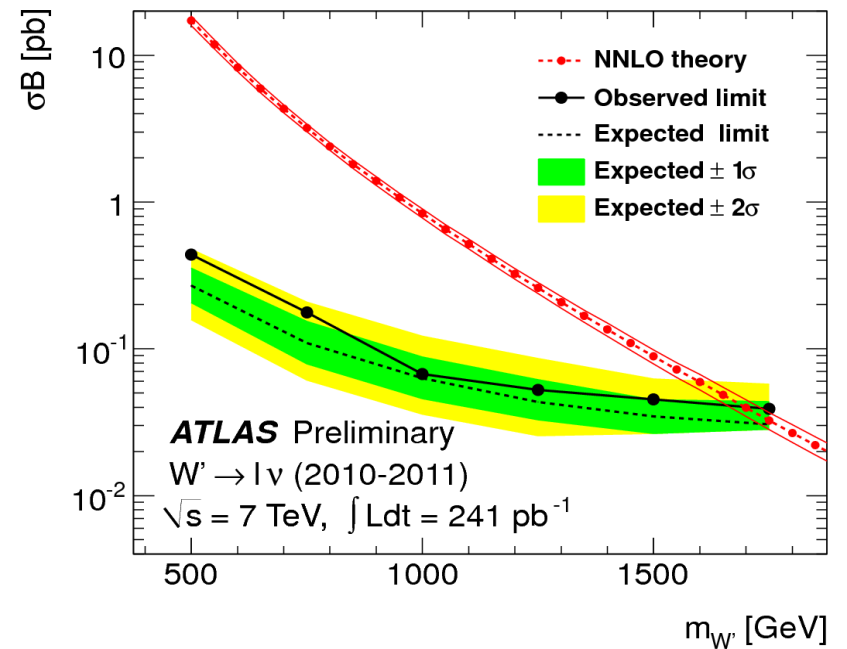


$$W' \rightarrow \mu\nu$$

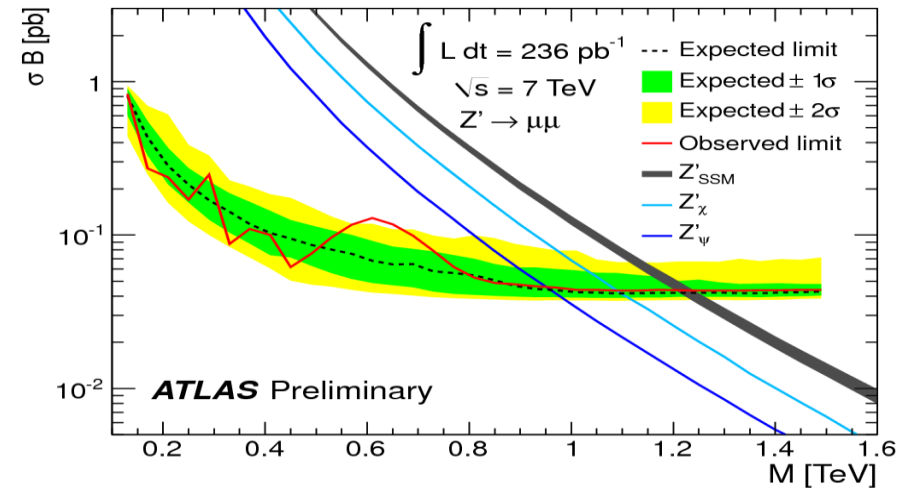
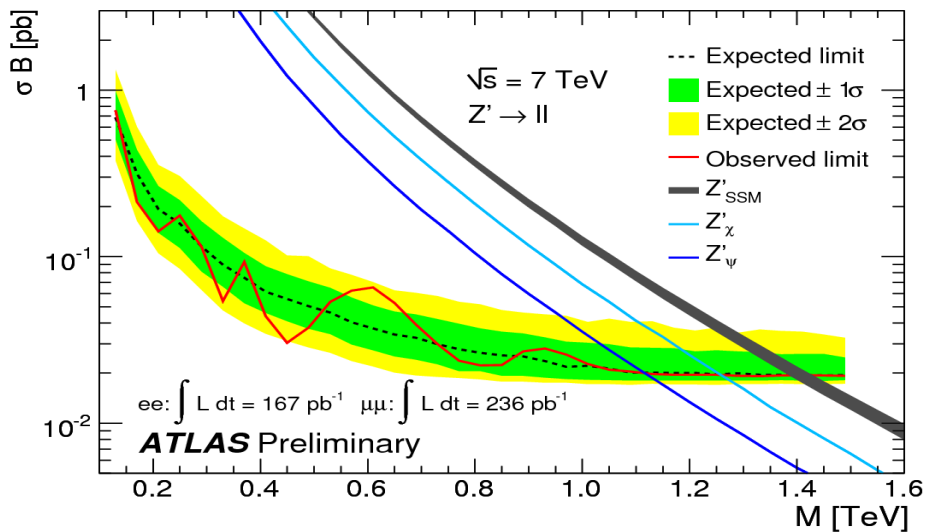
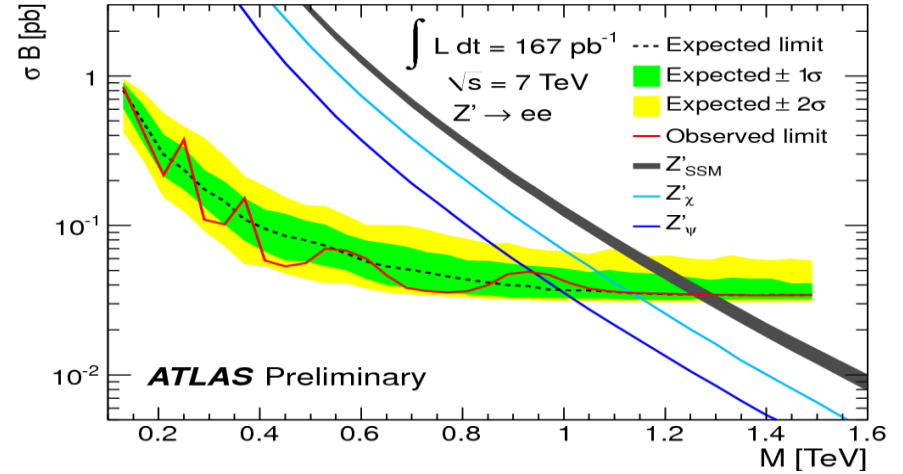
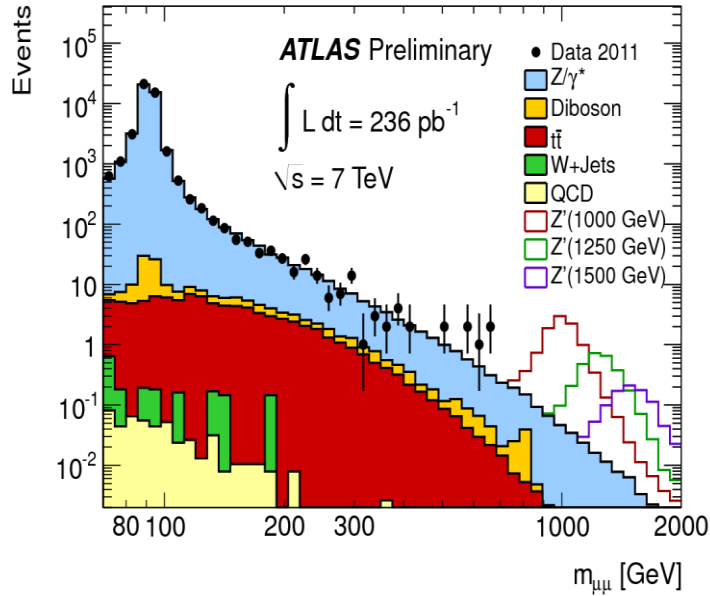


$M_{W'} > 1.70 \text{ TeV}$ for SSM W'

Limit: combination with previous ATLAS measurement



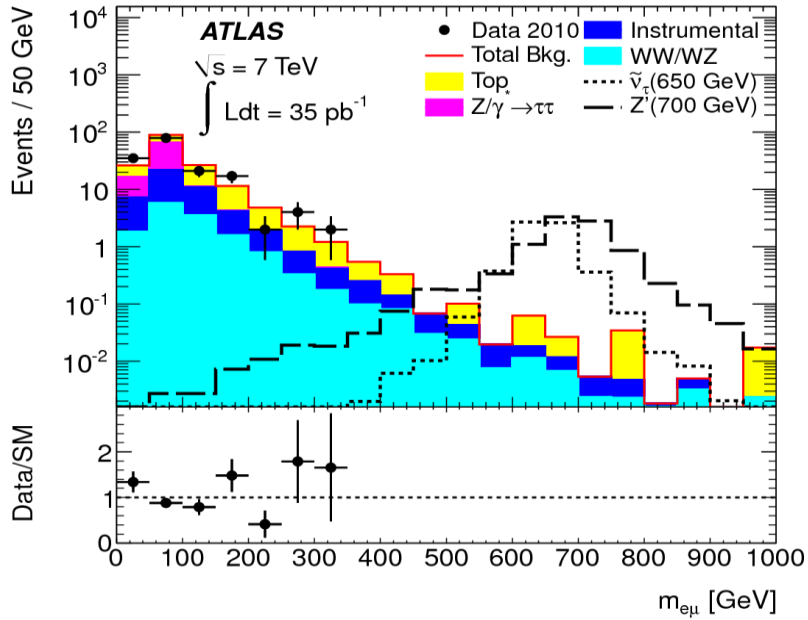
$Z' \rightarrow ee, \mu\mu$



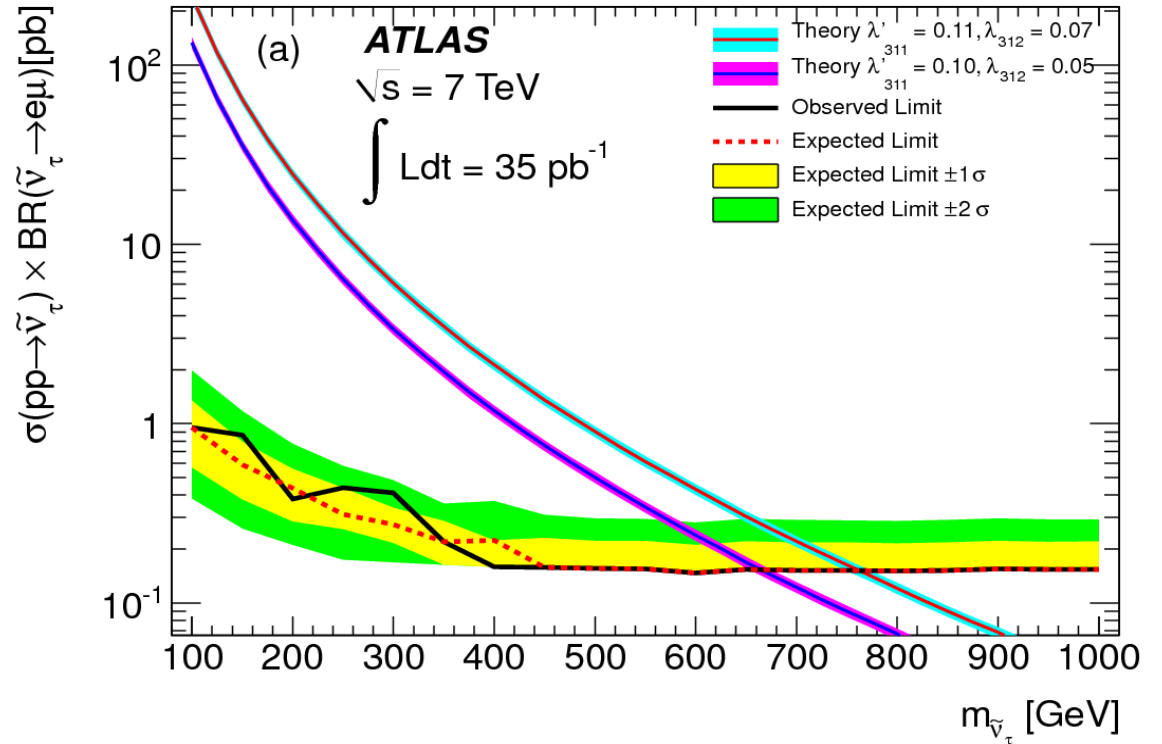
No significant excess above 110 GeV
 $M_{Z'} > 1.407 \text{ TeV}$ for sequential SM Z'

Mass limits on E6-motivated models as well.

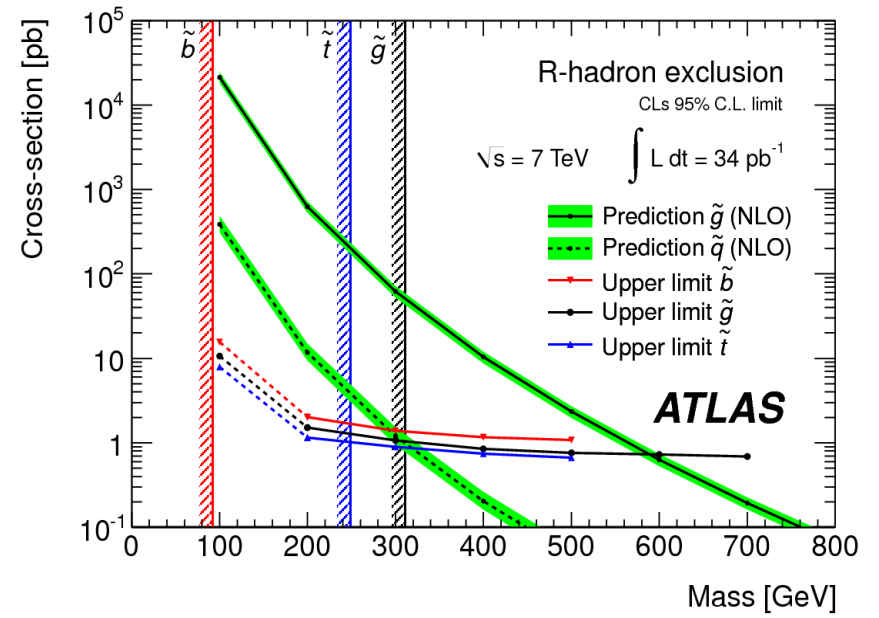
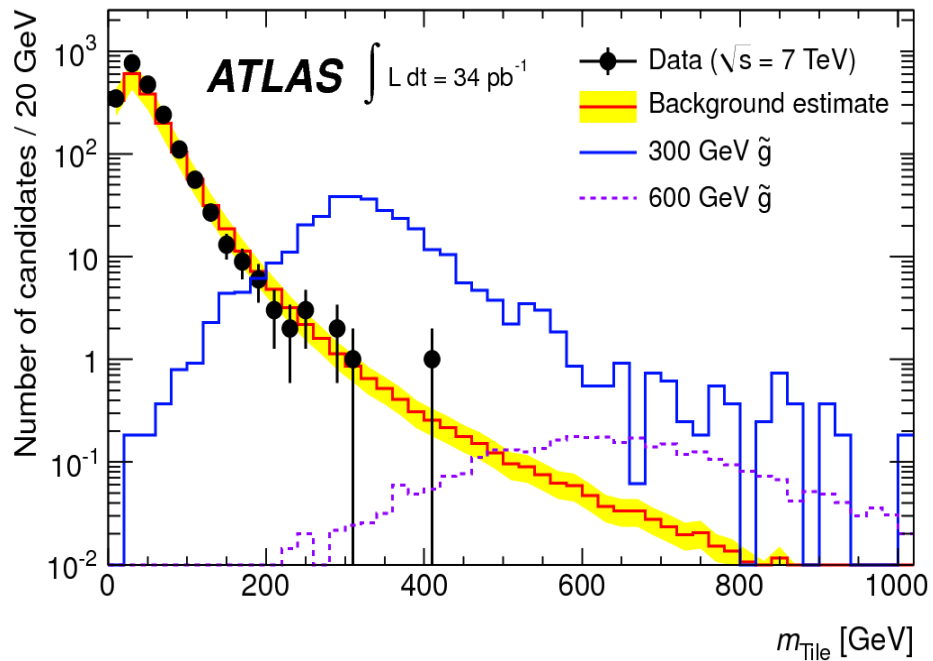
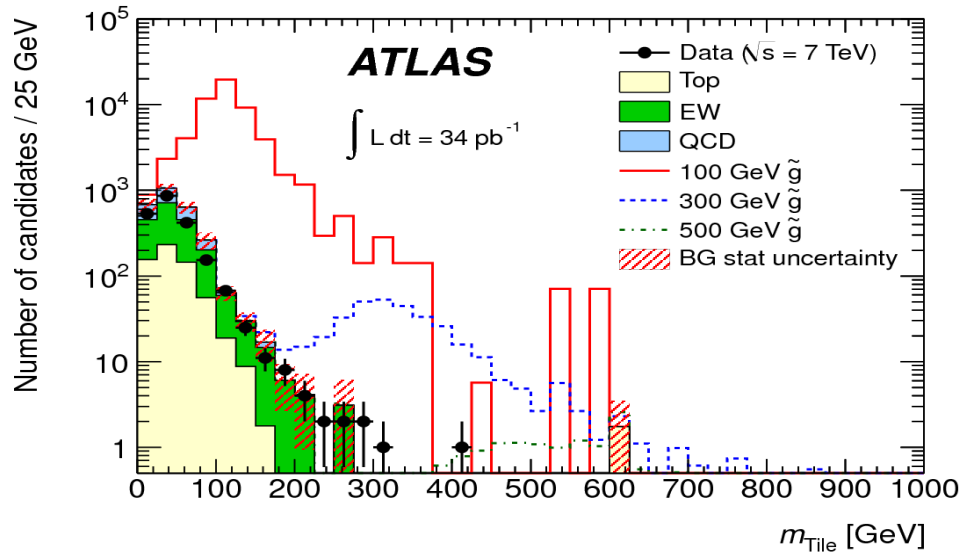
Heavy Particle $\rightarrow e\mu$



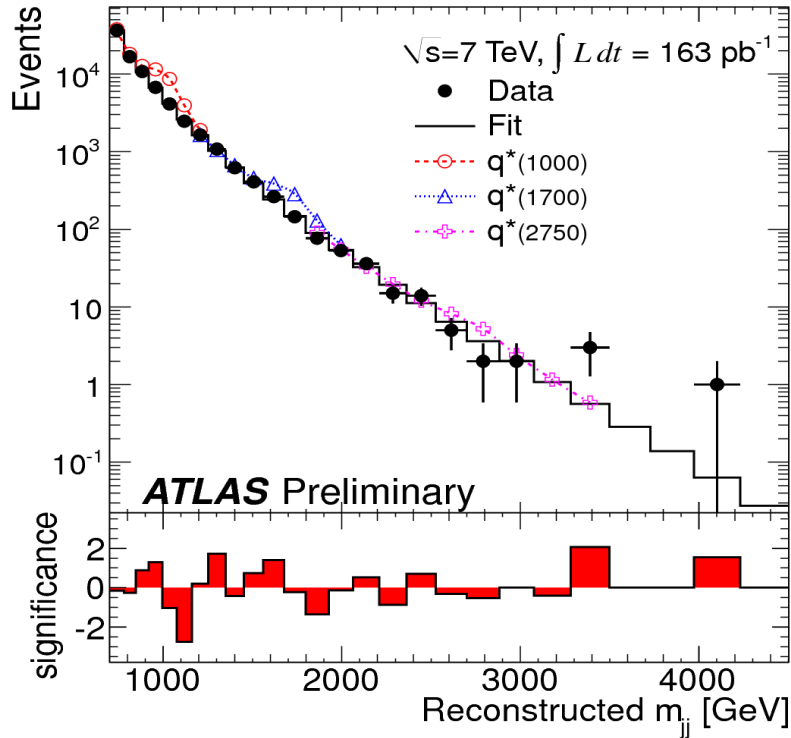
Z' or RPV SUSY



Stable Hadronizing Squarks and Gluinos



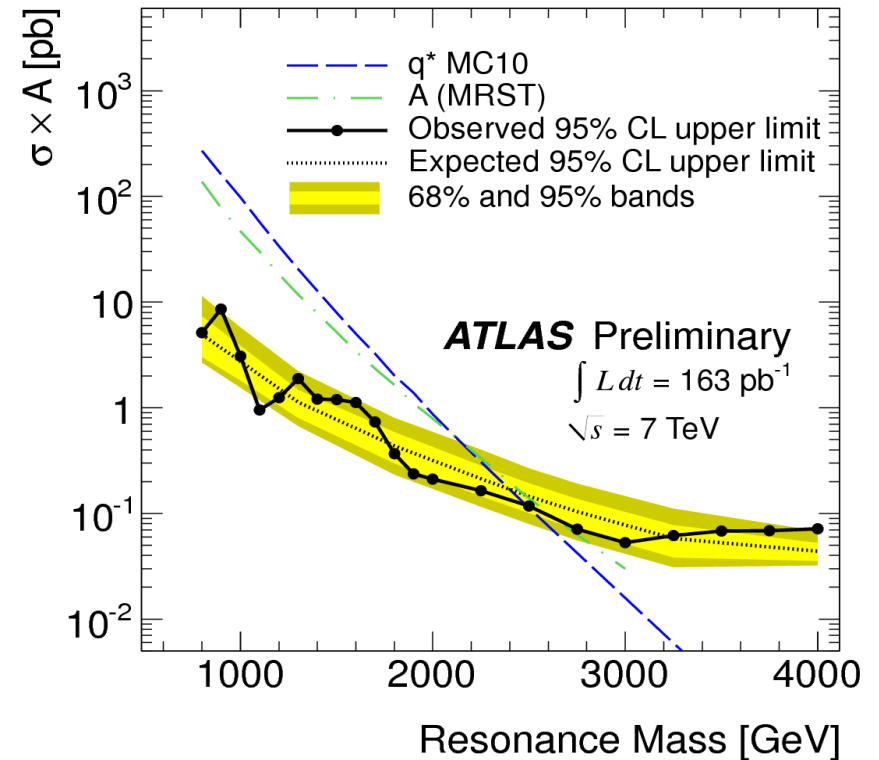
Di-jet Resonances



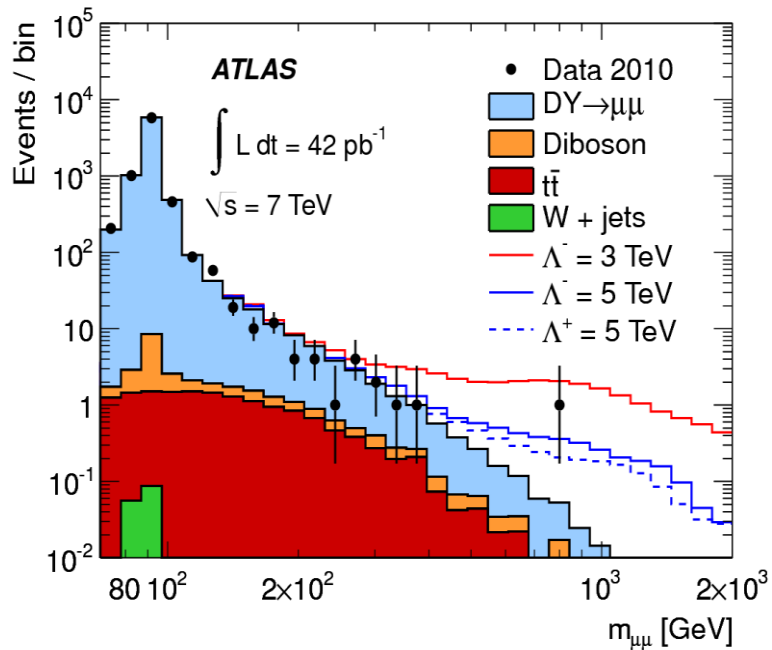
$$0.80 < M_{q^*} < 2.50 \text{ TeV}$$

$$0.80 < M_A < 2.67 \text{ TeV}$$

No excess observed
Limits on excited quark and axigluon masses



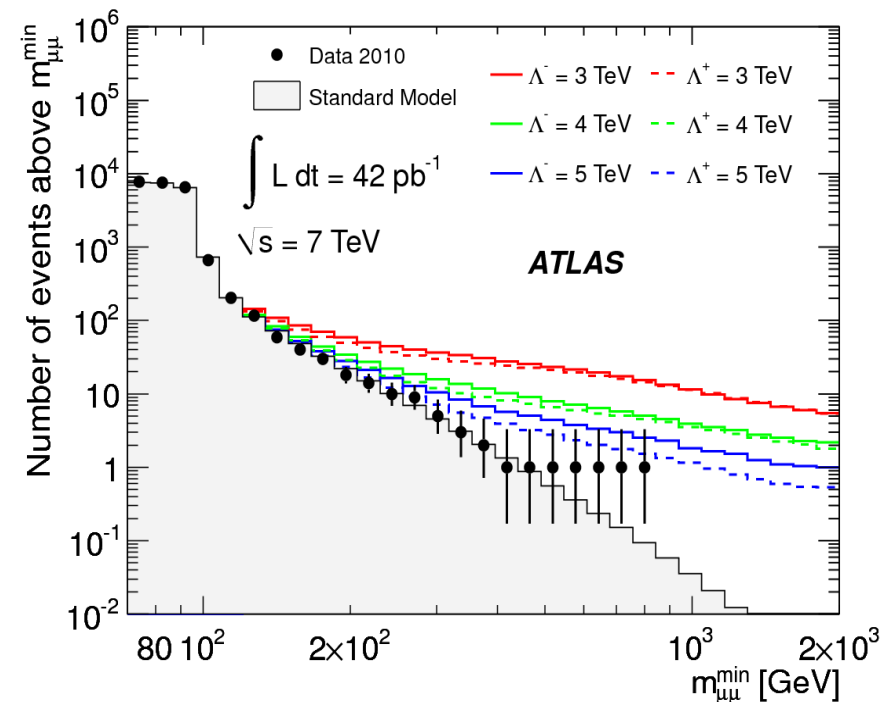
Contact Interactions in di-muon Events



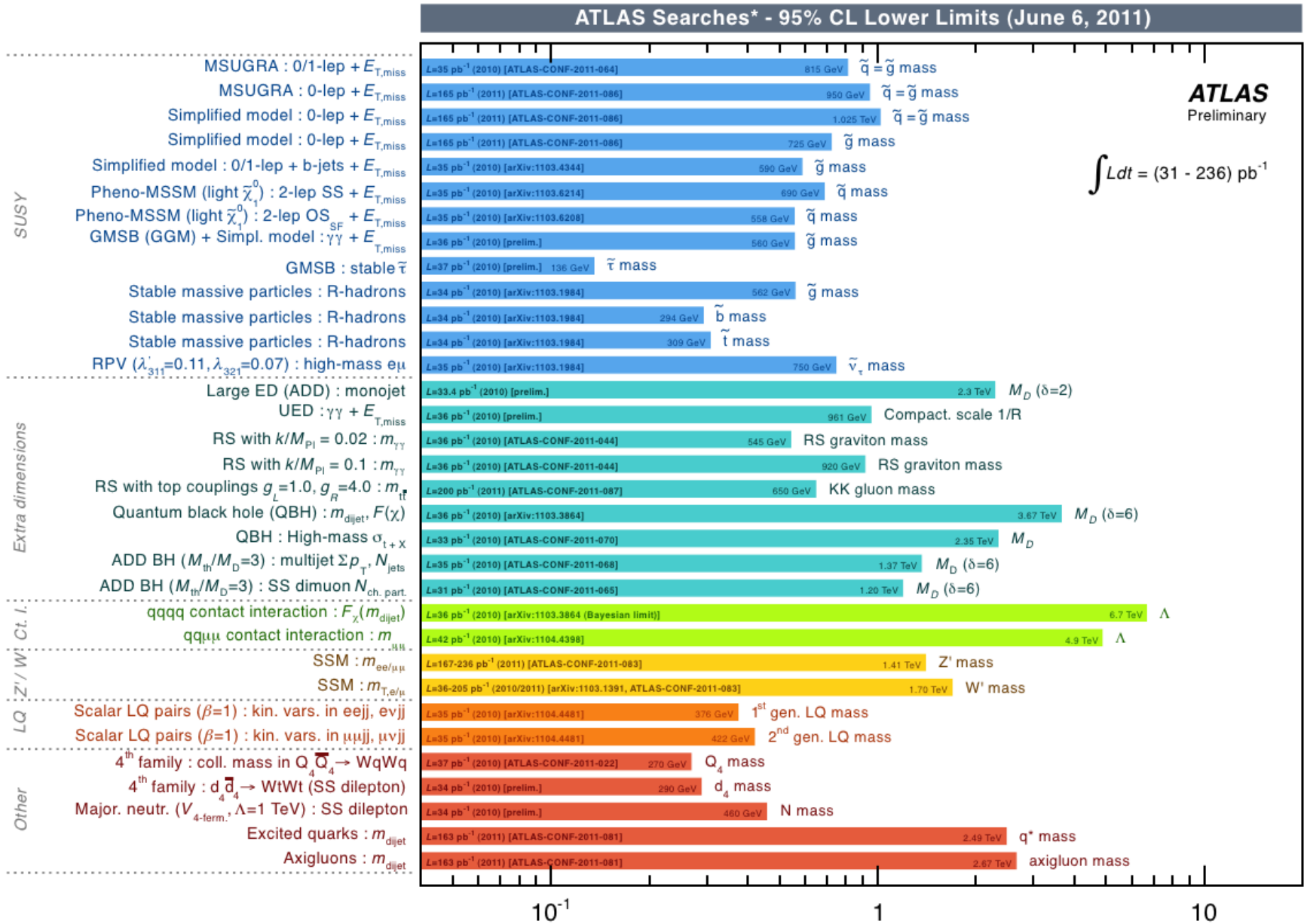
Limit on energy scale of contact Interactions

$\Lambda > 4.9 \text{ TeV}$ (constructive)

$\Lambda > 4.5 \text{ TeV}$ (destructive) interference



And many more...

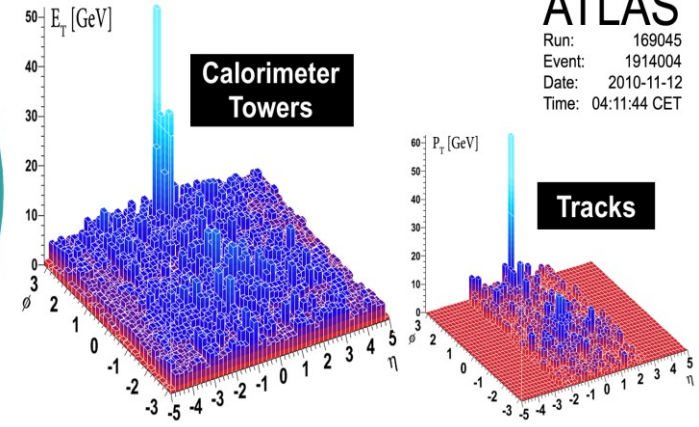
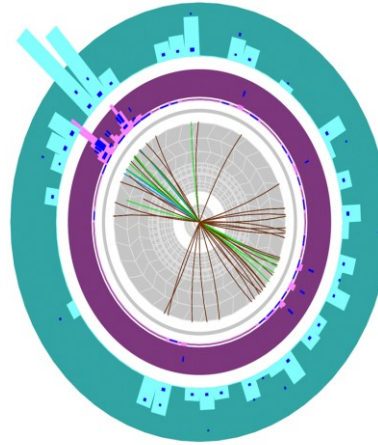
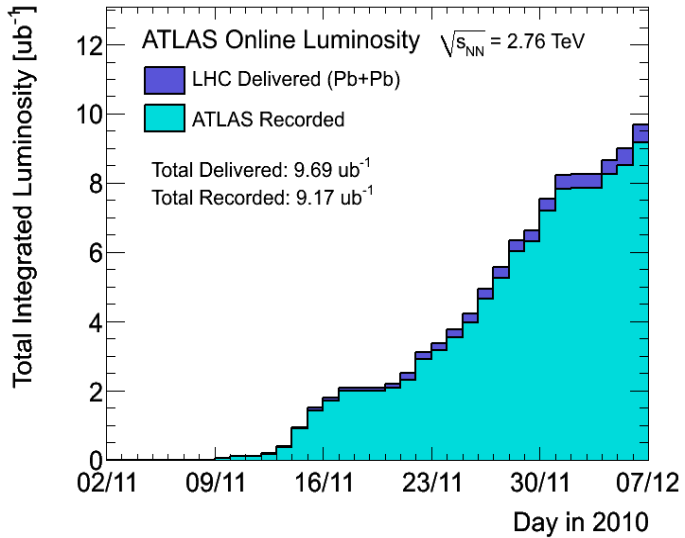


* Only a selection of the available results shown

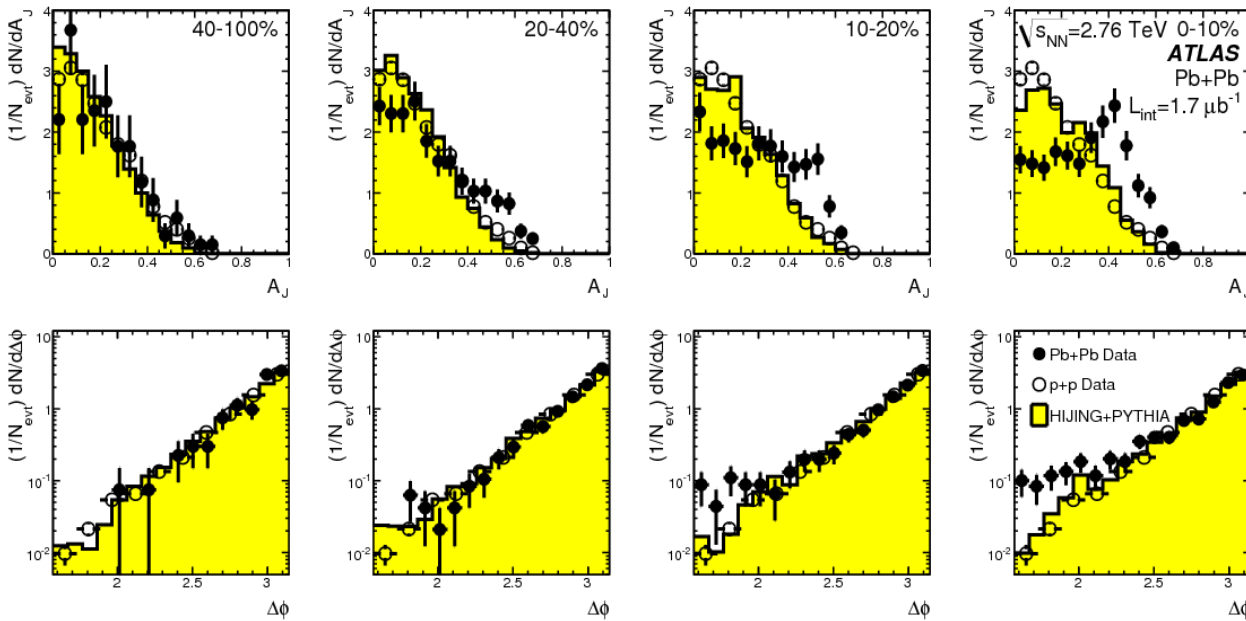
See also...

G. Unel: Search for New Physics at ATLAS
Monday, 17:40h

Heavy Ion Physics



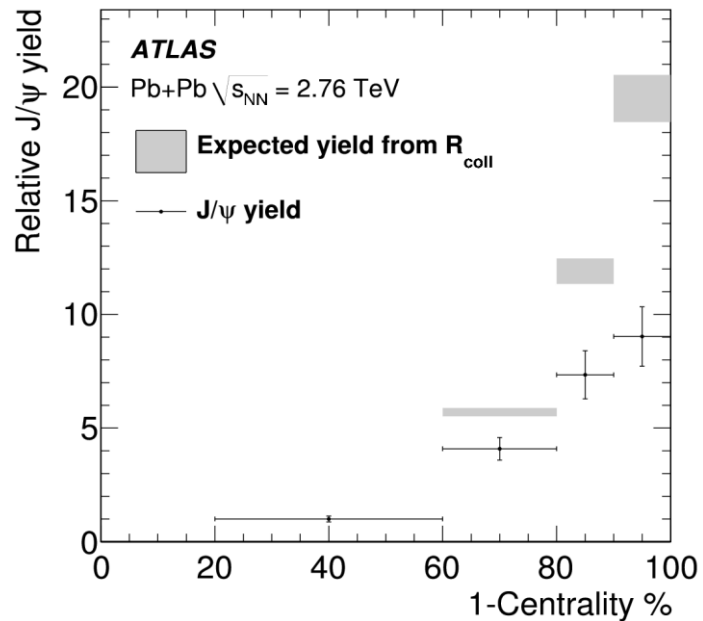
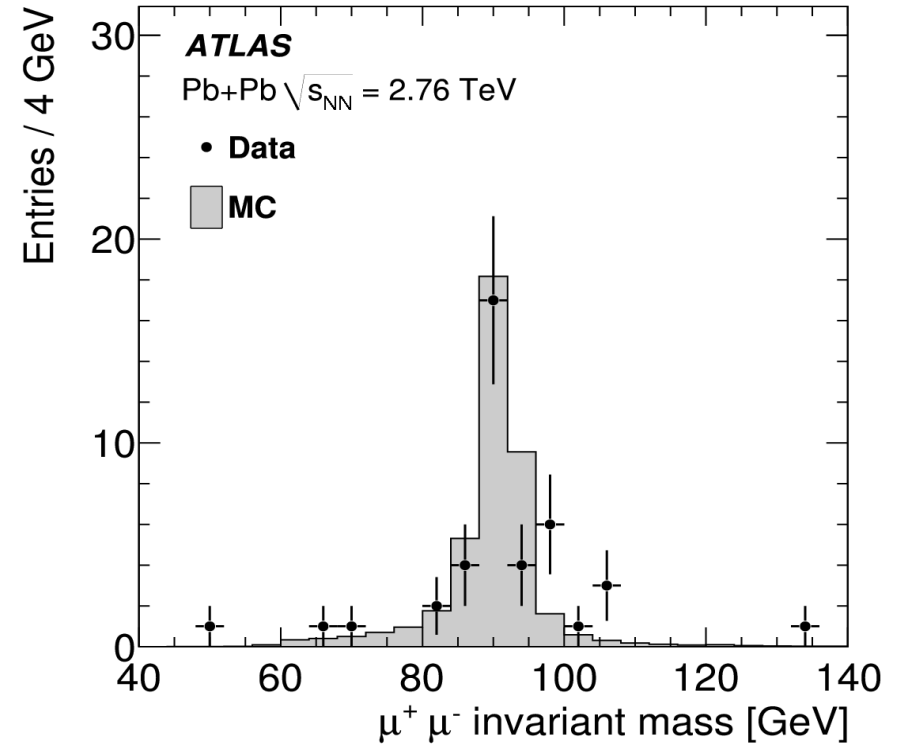
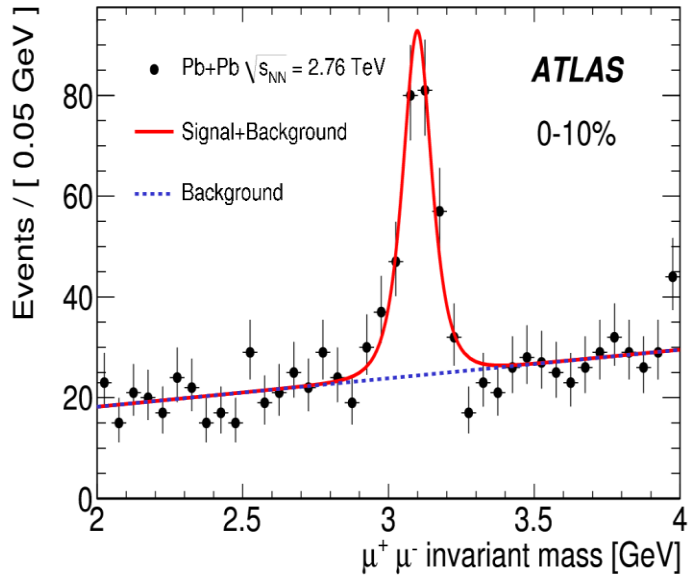
ATLAS
 Run: 169045
 Event: 1914004
 Date: 2010-11-12
 Time: 04:11:44 CET



Unbalance in jets

Jet quenching

Heavy Ion: J/Psi, Z $\rightarrow \mu\mu$



Summary

- ATLAS is taking data with high efficiency and excellent detector availability.
- 2010 was used to calibrate the detectors and rediscover the standard model – now we are setting new limits that exceed the Tevatron in many cases.
- More than 1 fb^{-1} is already recorded
- The excellent LHC performance make more than 3 fb^{-1} until the end of the year look realistic
 - Exciting times ahead !

More Information

- ATLAS Public Results Page:
 - <https://twiki.cern.ch/twiki/bin/view/AtlasPublic/WebHome>