Results from ATLAS

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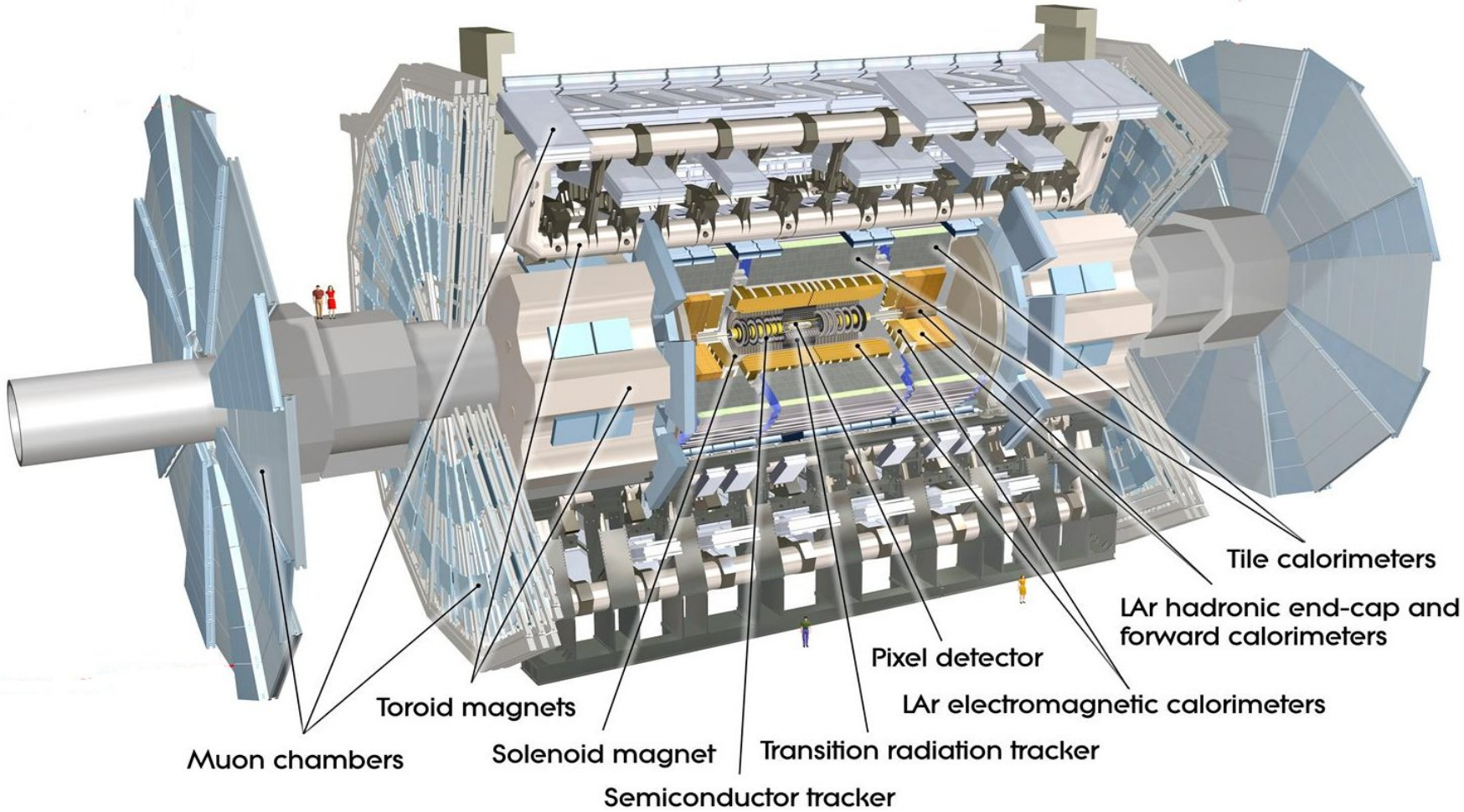
for the ATLAS collaboration

XIX International Workshop on Deep-Inelastic Scattering and Related Subjects

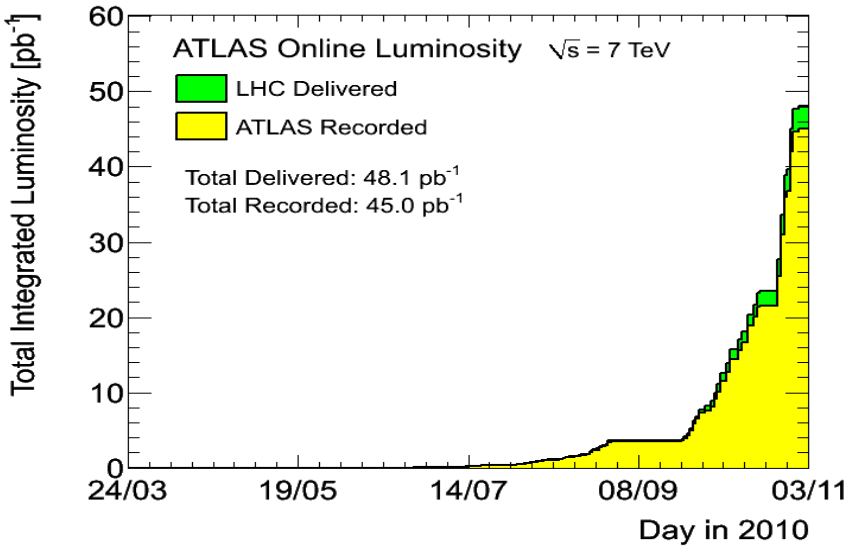
Outline

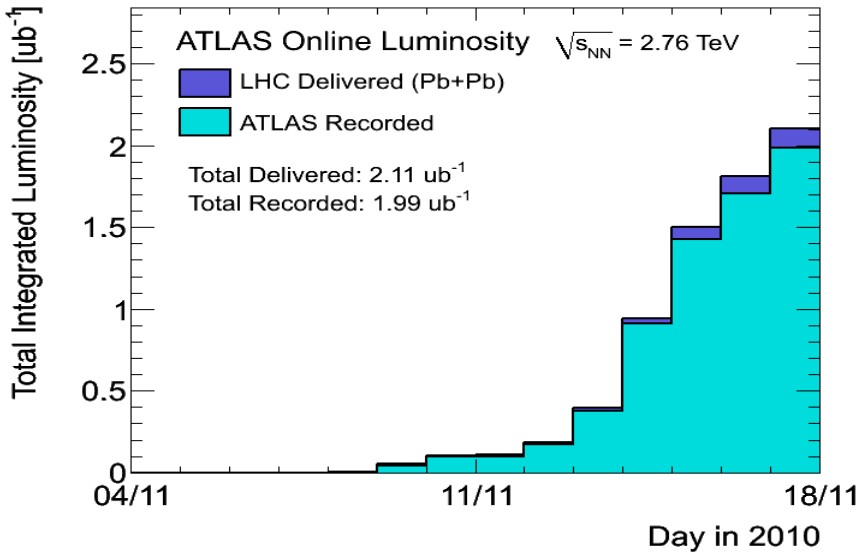
- ATLAS detector status
- Performance
  - Electron, muon, jet, b-tagging, E_T^{miss}
- Physics highlights
  - Standard Model measurements
    - Soft QCD, Prompt photon, B, W/Z, Jet, Top
  - Higgs search
  - Searches for new physics
    - Exotics, SUSY
- Summary

ATLAS Detector



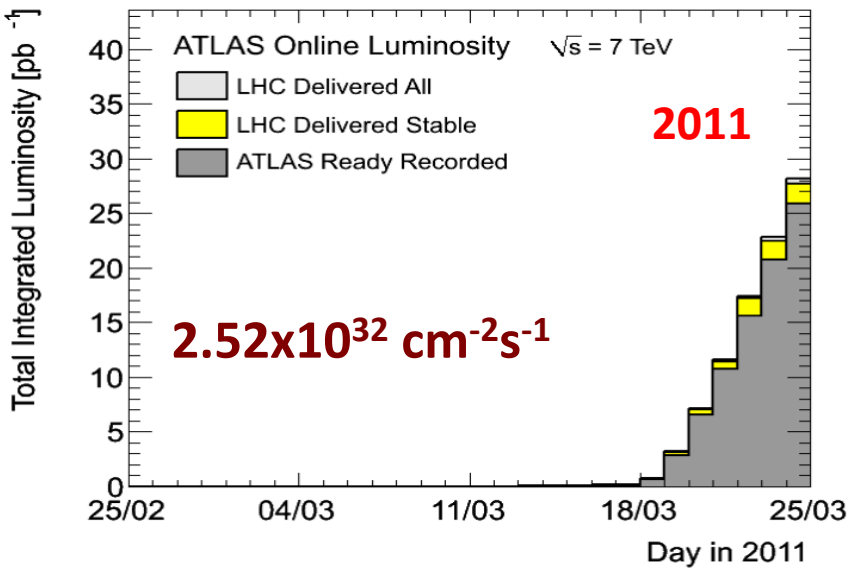
Luminosity





- **ATLAS recorded ~94% in2010**
- **2.1×10^{32} $cm^{-2}s^{-1}$ reached in 2010**
- **Exciting 2011 ahead**

3.4% uncertainty on luminosity measurement; a factor of 3 improvement



Detector Status

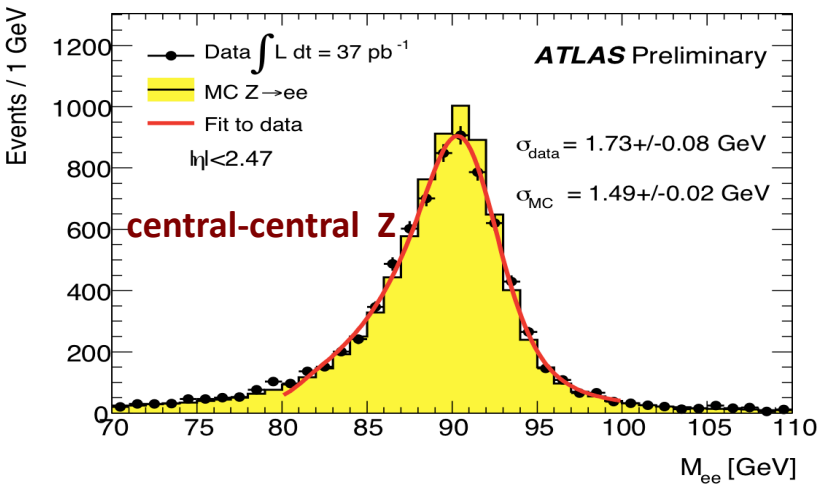
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.3%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	97.1%
LAr EM Calorimeter	170 k	97.9%
Tile calorimeter	9800	96.8%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo 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	99.5%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	98.4%

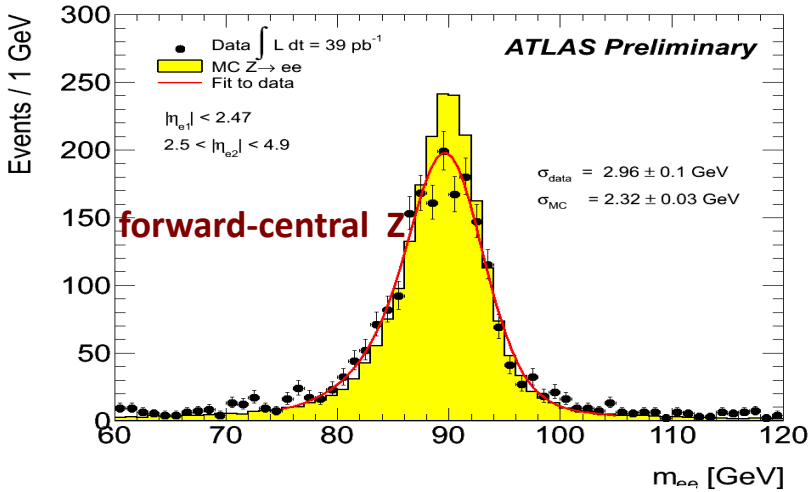
Performance

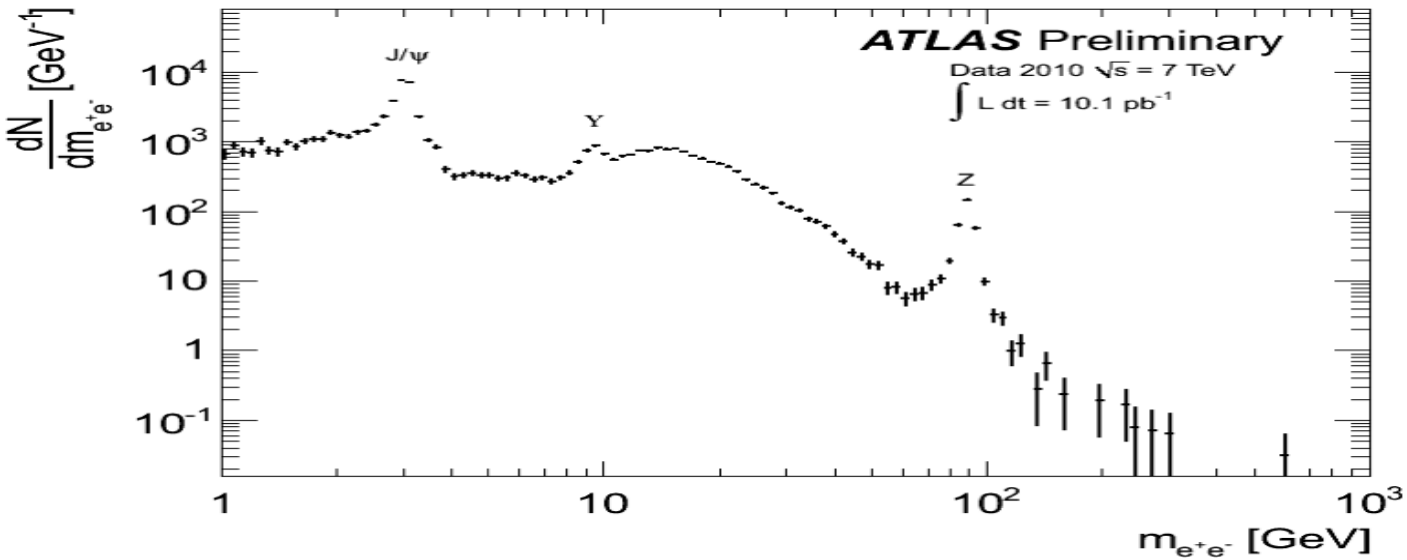
e, μ, jet, b-tagging, E_T^{miss}

Electron

- Good di-electron mass resolution (even for forward-central)
- Good linearity seen with calibration at Z peak

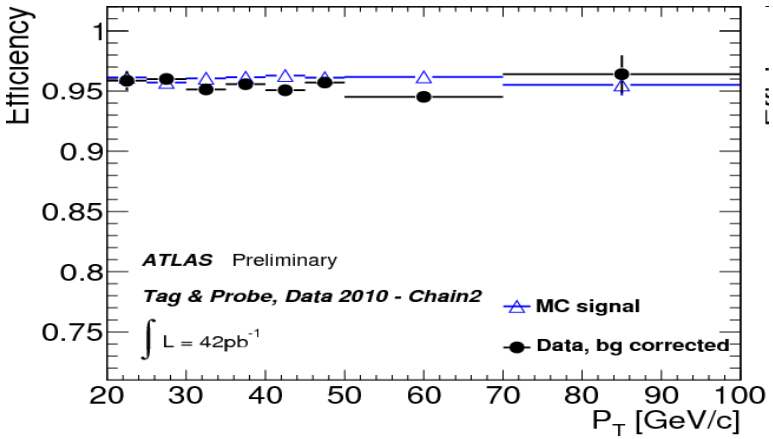


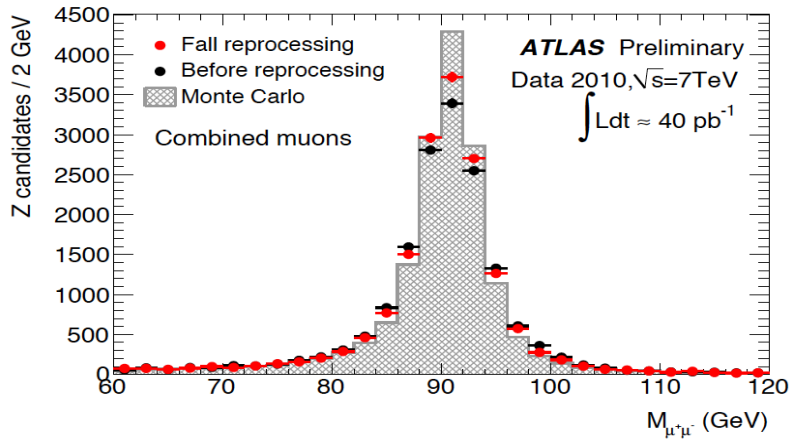


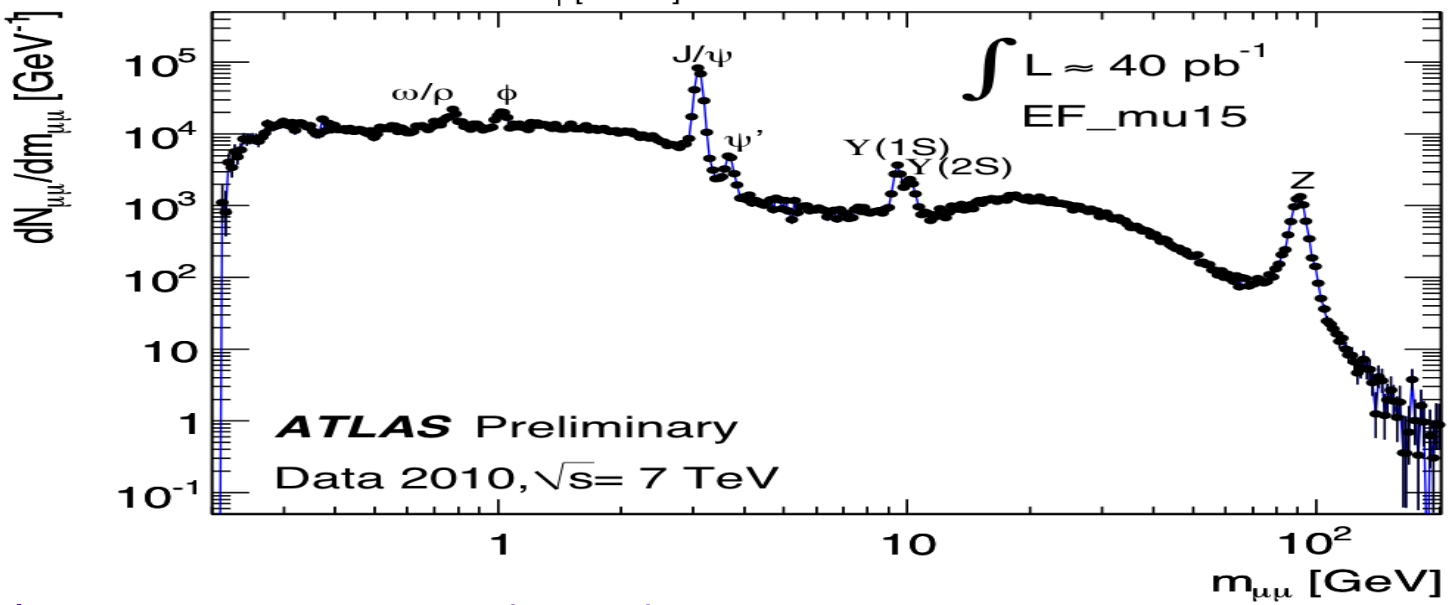


Muon

- **Efficiency understood well down to very low P_T**
- **Excellent dimuon mass resolution (barrel 1.8%, endcap 3%)**

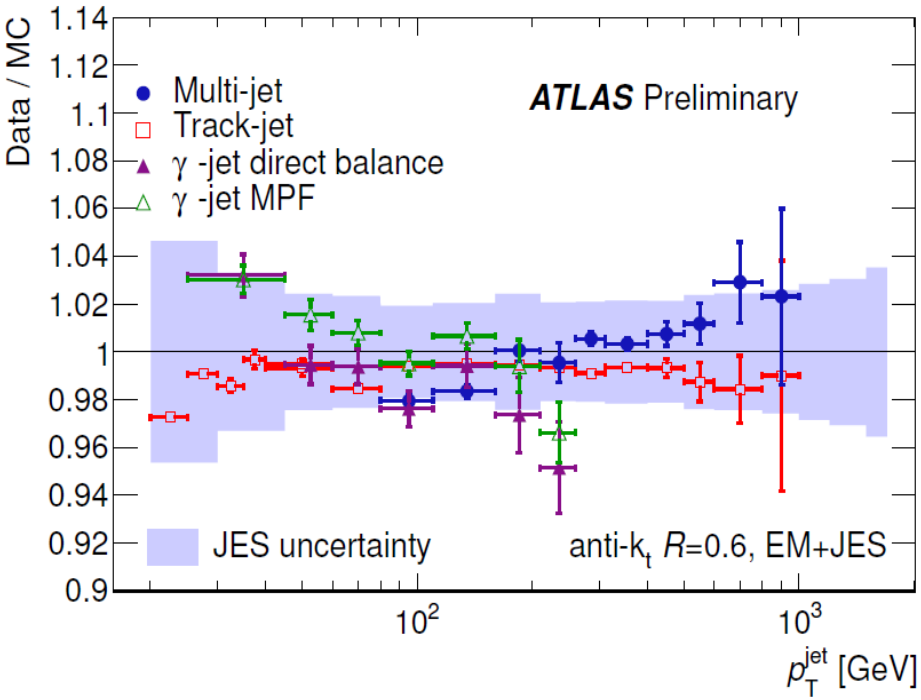


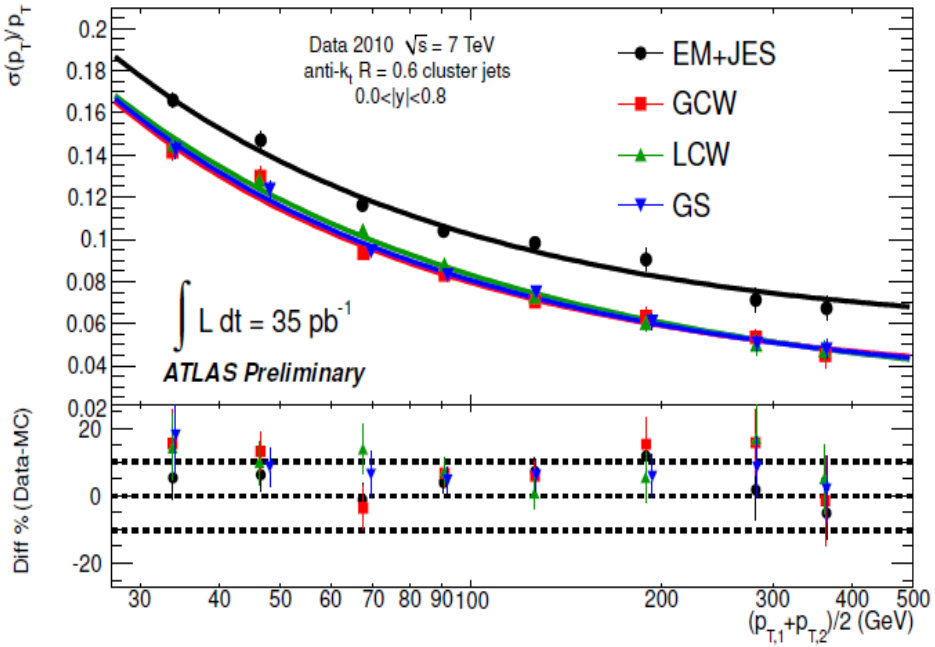




Jet Energy Scale & Resolution

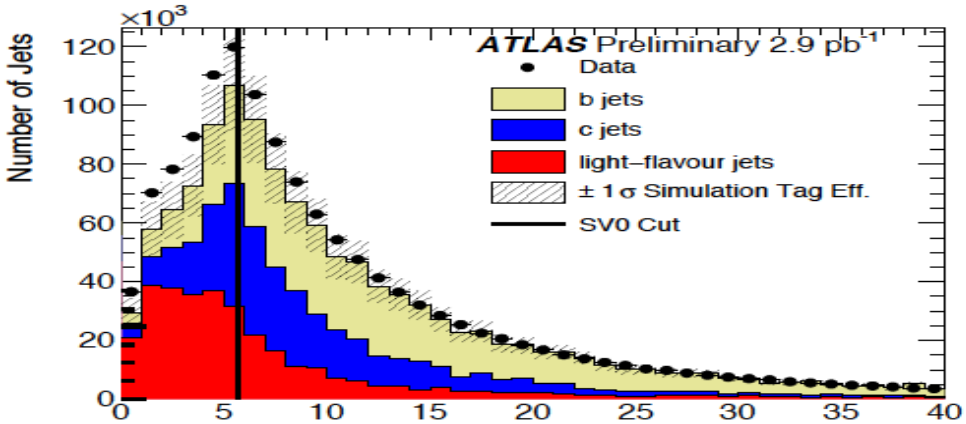
- Jet energy scale evaluated in $P_T < 3.5$ TeV, $|\eta|<4.5$
- Jet energy scale uncertainty 2-4% for $P_T > 20$ GeV in central region
- Good energy resolution, data and MC agree within 10%



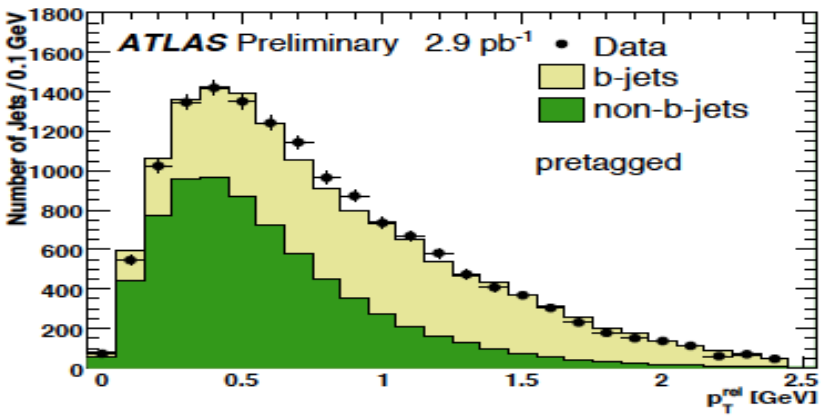


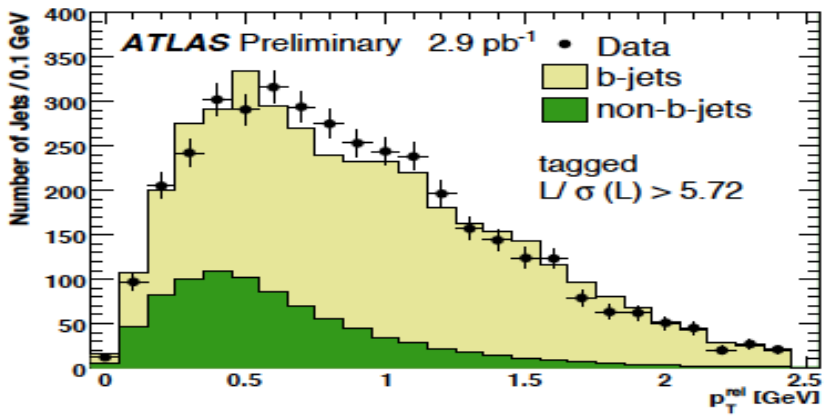
b-tagging

- Important for top physics and Higgs search
- Secondary vertex tagger as one of the algorithms
  - Tag efficiency 40% - 60% in 25 GeV < p_T < 85 GeV
  - Mistag rate 0.2 - 1% in 20 GeV < p_T < 150 GeV



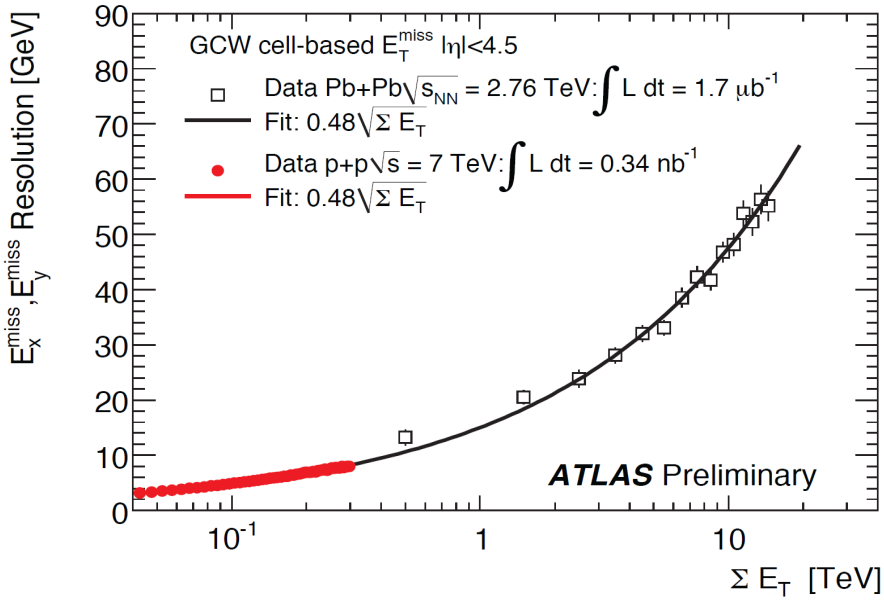
The signed decay length significance

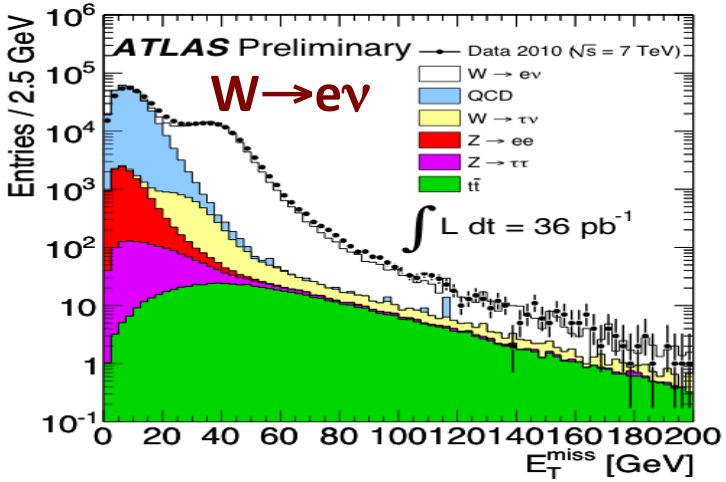


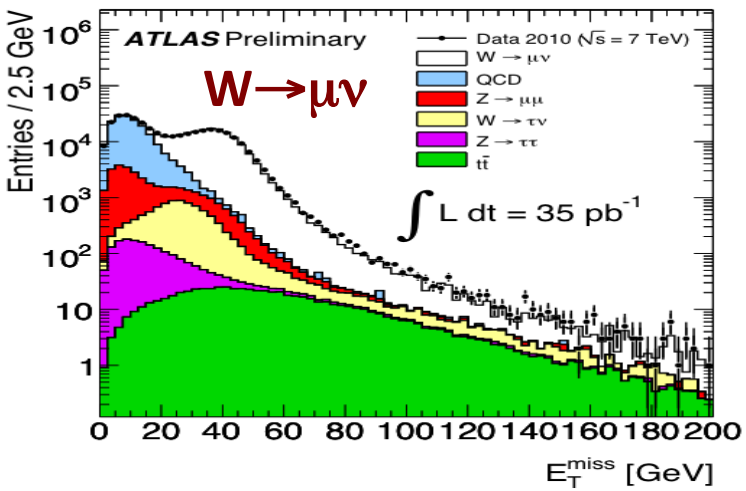


Missing Transverse Energy (E_T^{miss})

- **ΣE_T reached 14.5TeV with Pb-Pb data**







Standard Model Measurements

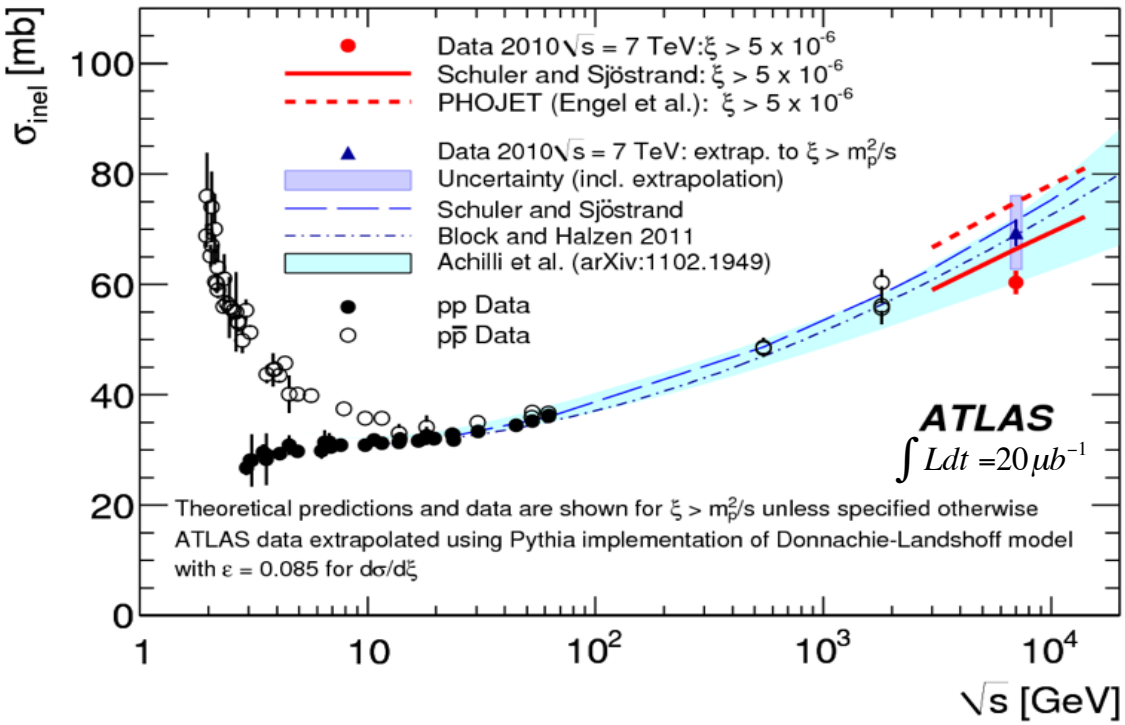
Soft QCD, Prompt photon, B, W/Z, Jet, Top

Soft QCD: Inelastic Cross Section

arXiv:1104.0326

- Measurement of the inelastic cross section
- Measuring in $\xi = M^2_X/S > 5X10^{-6}$ but extrapolating to the full ξ range
- Consistent with theoretical predictions

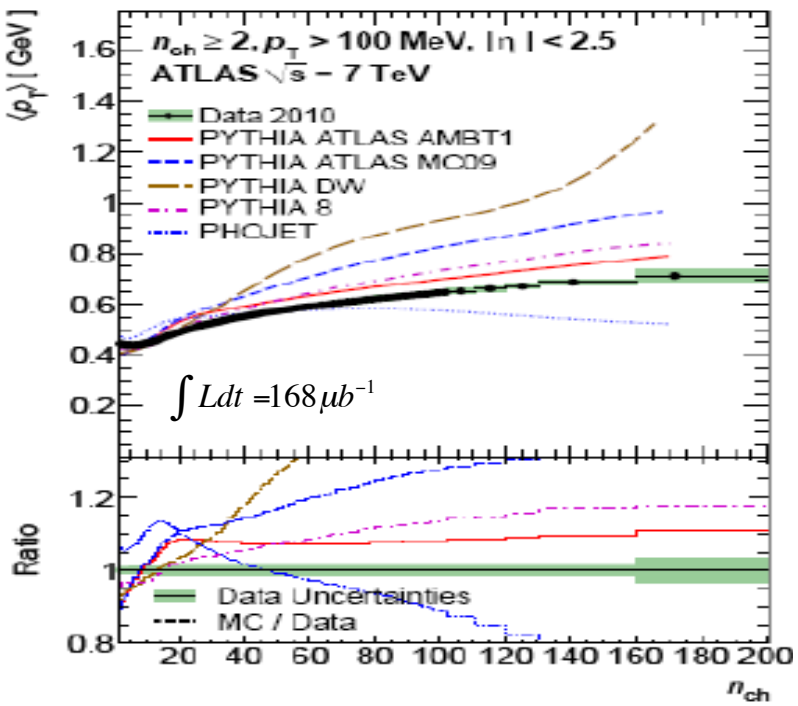
$$\sigma_{inel}(\xi > 5 \times 10^{-6}) = 60.3 \pm 0.05(\text{stat}) \pm 0.5(\text{syst}) \pm 2.1(\text{lumi})\ \text{mb}$$

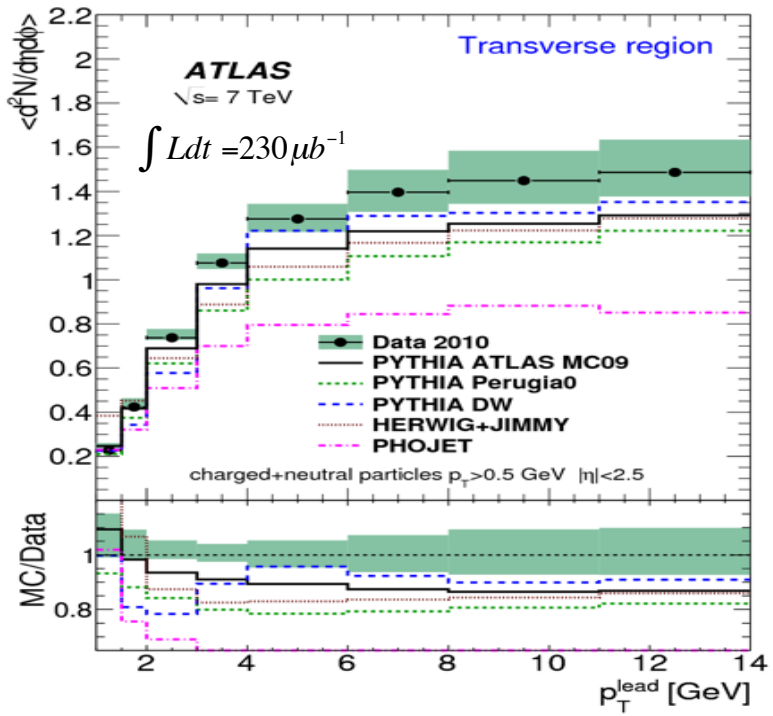


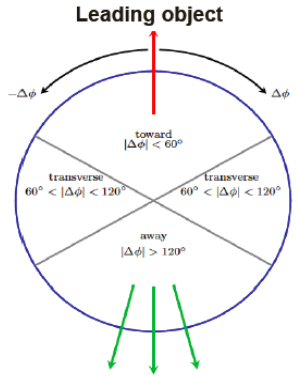
Soft QCD: MB & UE

arXiv:1012.5104
arXiv:1103.1816

- Minimum bias measurement using charged tracks with P_T > 100 MeV
- Underlying event measurement using charged & neutral particles
- Better tunes of models, important input for hard process measurements

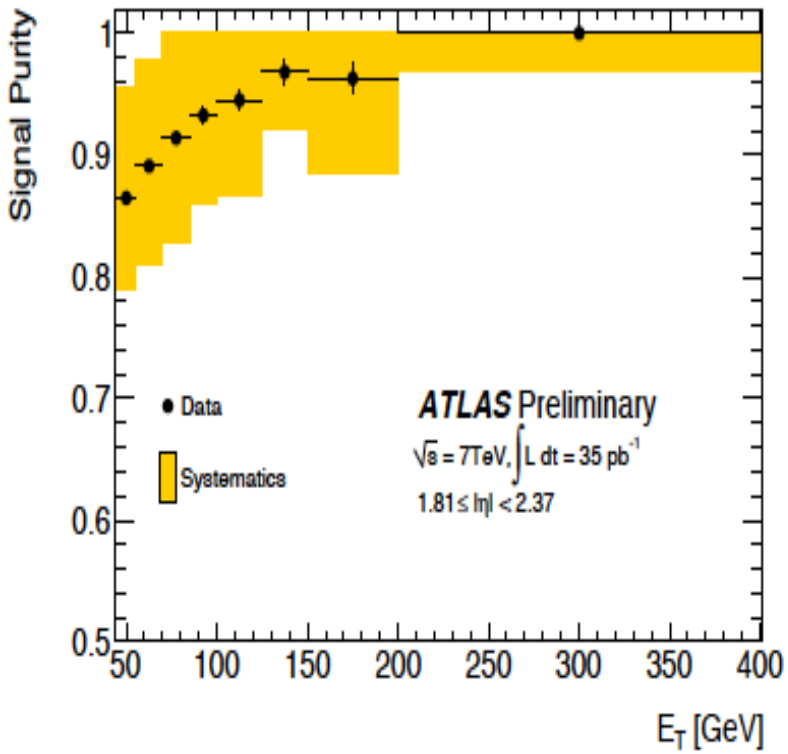


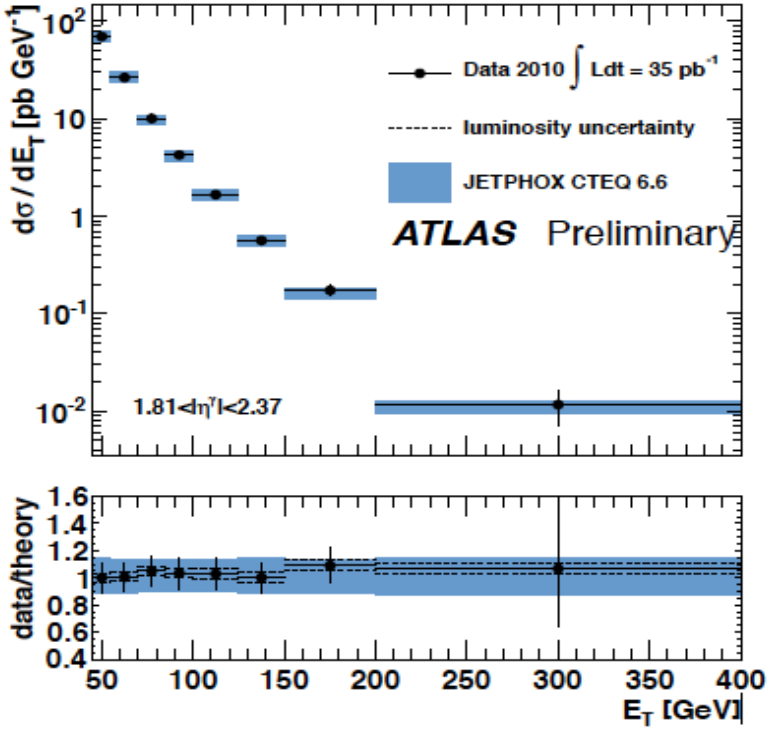




Prompt Photon Cross Section

- **Measurement of the cross section for the inclusive production of isolated prompt photon**
- **Good agreement between the data and the NLO calculation**



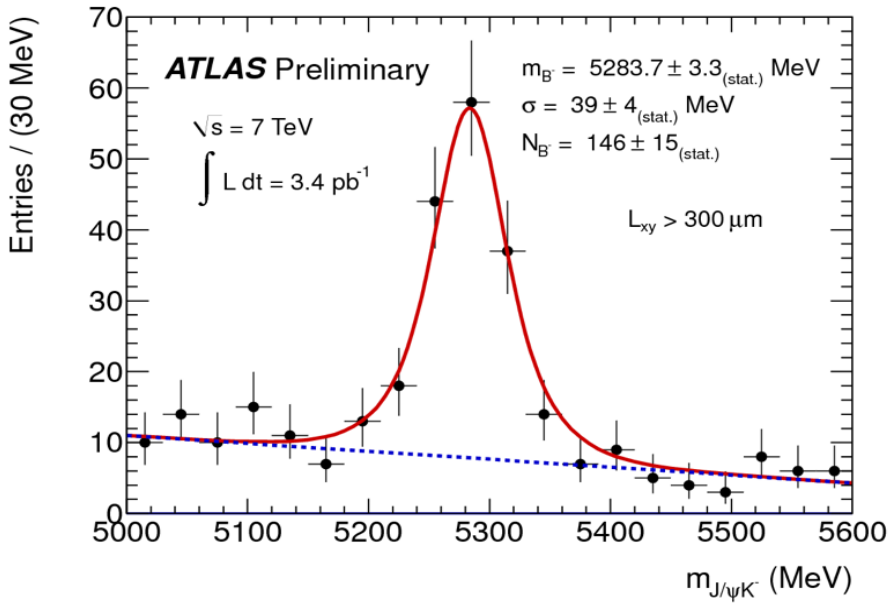


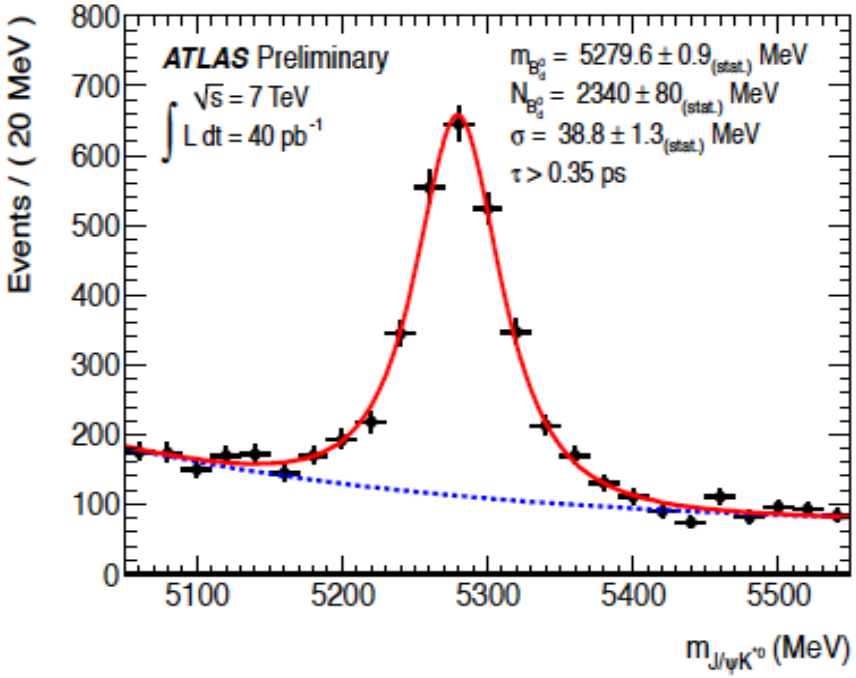
B Production

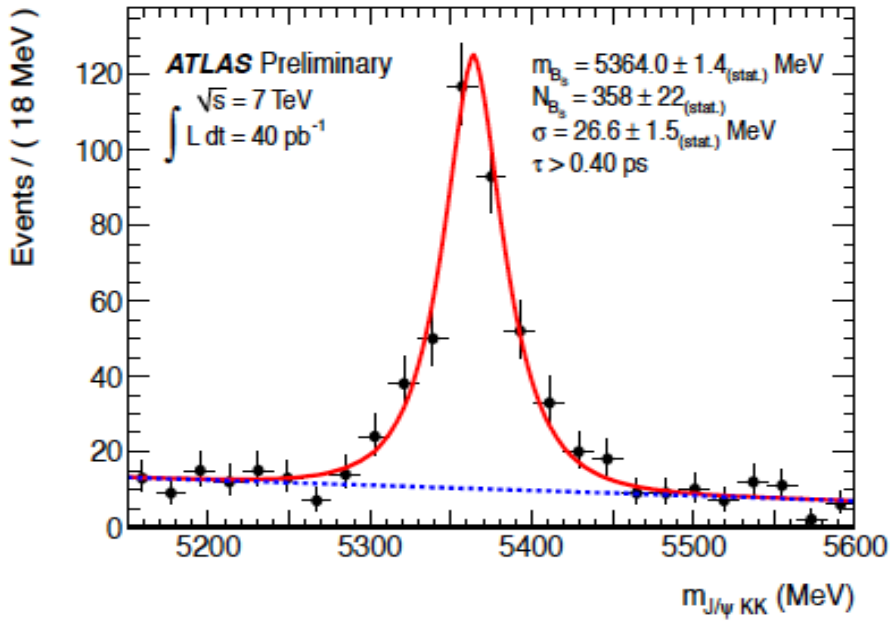
ATLAS-CONF-2010-098

ATLAS-CONF-2011-050

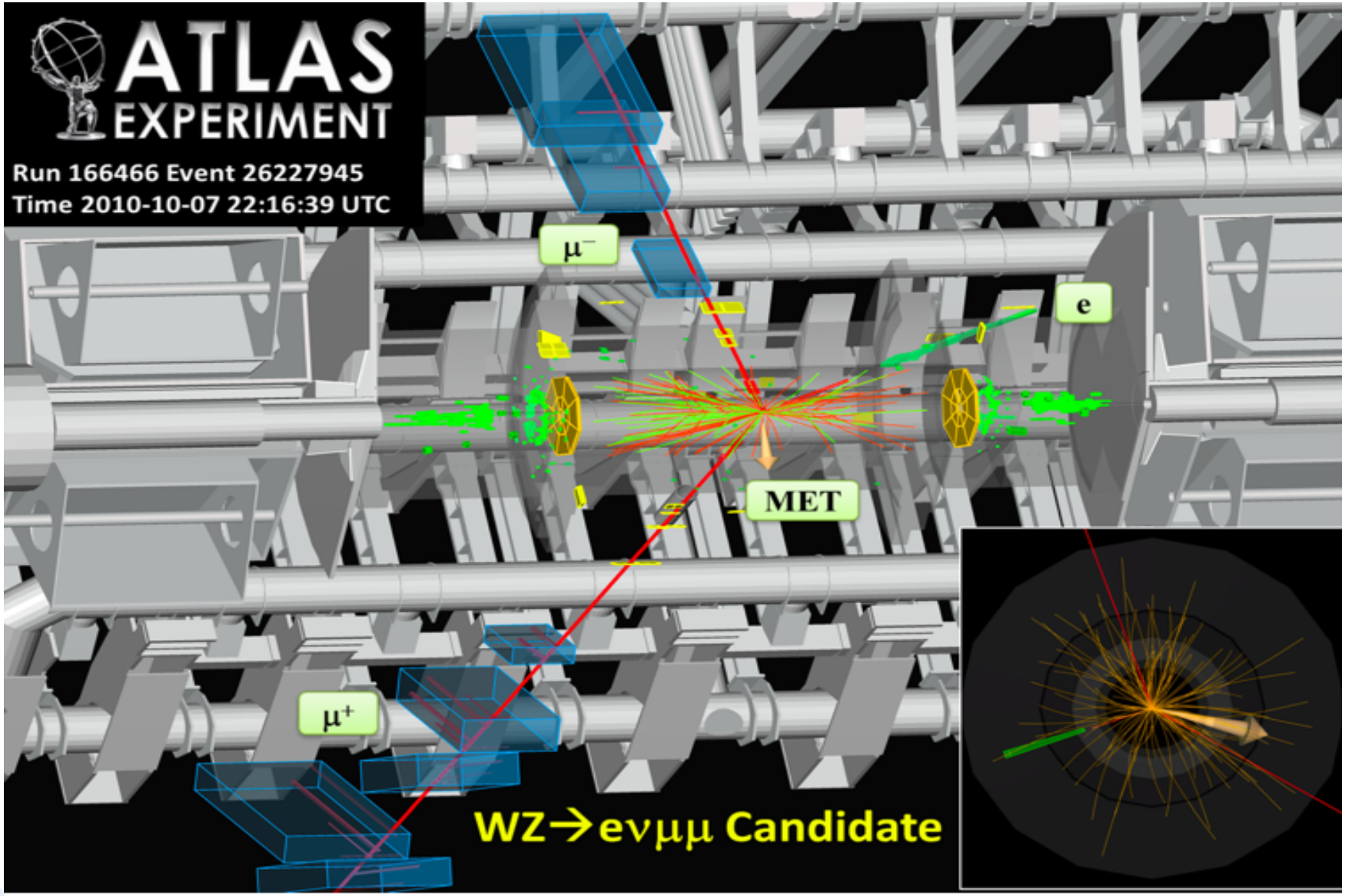
- $B^{\pm} \rightarrow J/\Psi(\mu\mu)K^{\pm}$
- $B^{0} \rightarrow J/\Psi(\mu\mu)K^{*0}$
- $B_S \rightarrow J/\Psi(\mu\mu)\phi$







W/Z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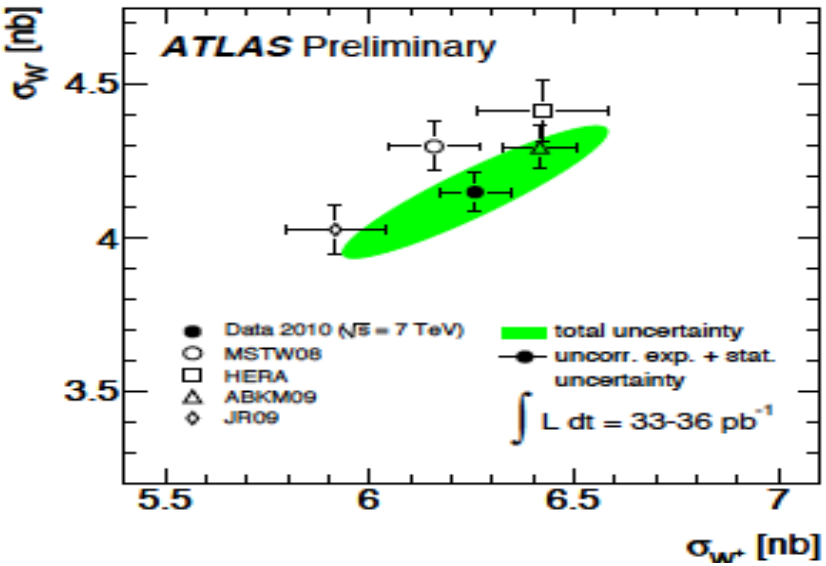
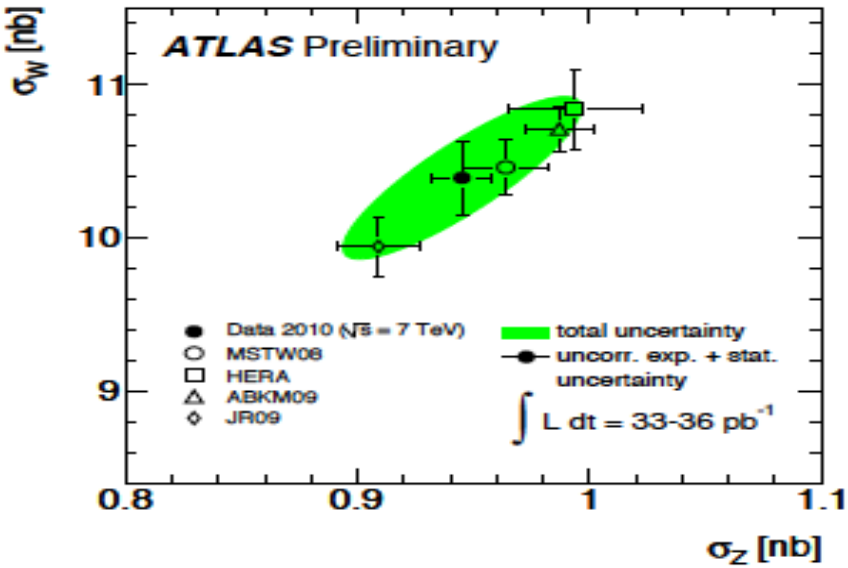
Time 2010-10-07 22:16:39 UTC
μ⁻
e
MET
μ⁺
WZ→eνμμ Candidate

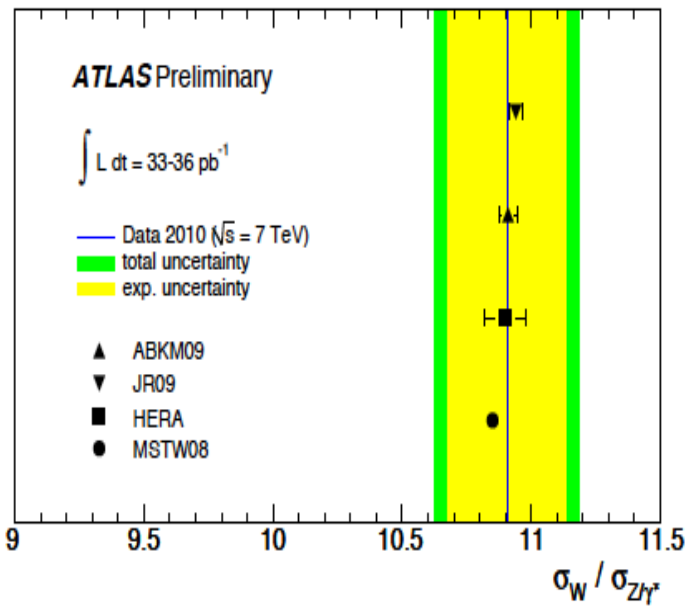
W & Z Cross Section

ATLAS-CONF-2011-041





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



The largest error from the luminosity

NNLO predictions consistent with data

Remarkable success of pQCD and PDFs

Diboson Production

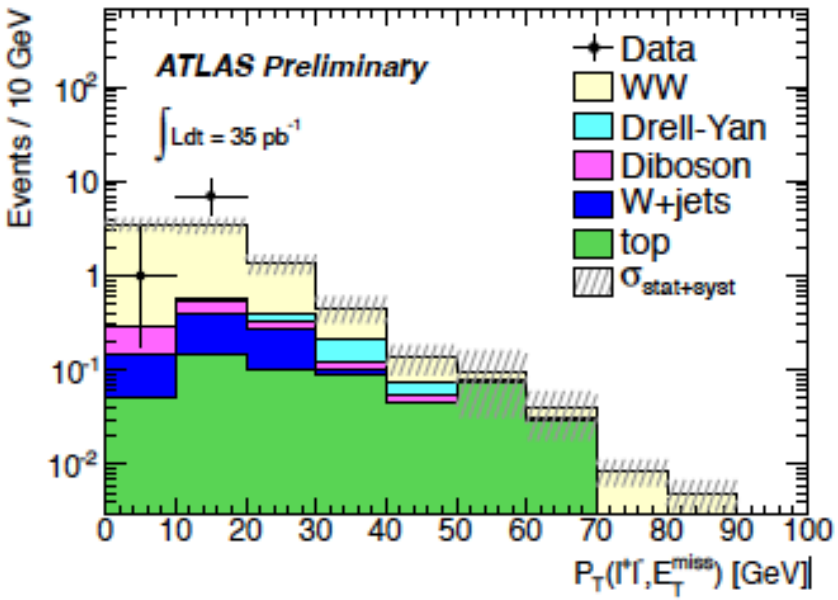
ATLAS-CONF-2011-015

ATLAS-CONF-2011-013

WW

- Sensitive to Triple Gauge Couplings
- Main background to H → WW
- NLO prediction 44.9 ±2.2 pb

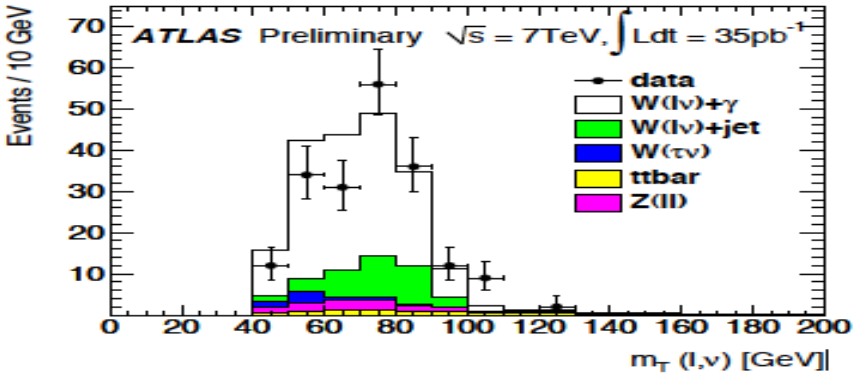
$$\sigma_{WW} = 40^{+20}_{-16}(\text{stat}) \pm 7(\text{syst})\ \text{pb}.$$

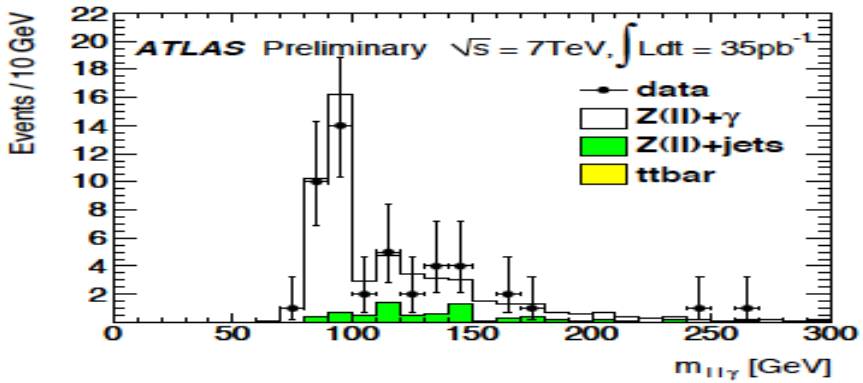


W/Z+γ

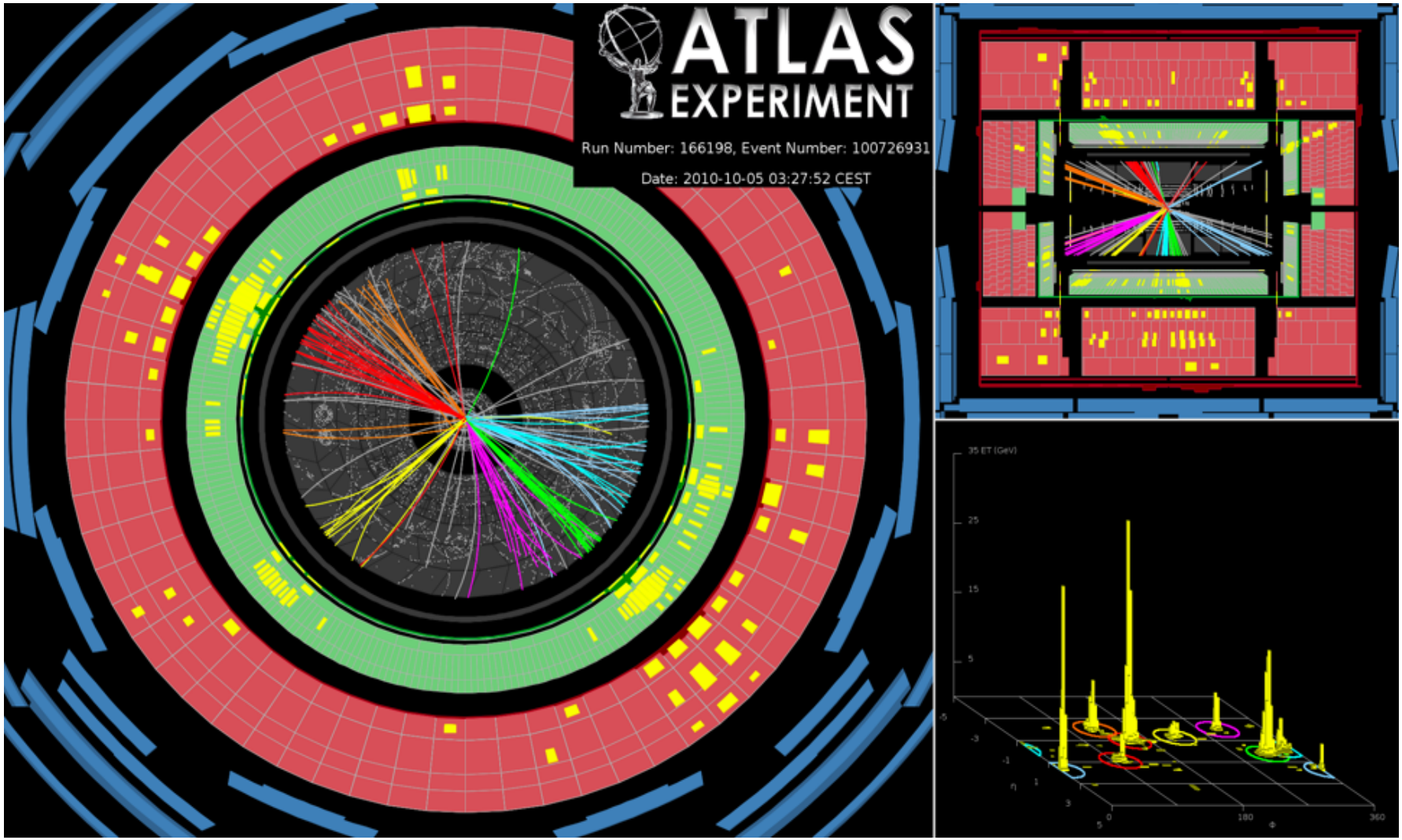
- Sensitive to Triple Gauge Couplings

	$\sigma^{total}[pb]$(measured)	$\sigma^{total}[pb]$(predicted)
$pp \to e\nu\gamma$	$73.9 \pm 10.5(stat) \pm 14.6(syst) \pm 8.1(lumi)$	$69.0 \pm 4.6(syst)$
$pp \to \mu\nu\gamma$	$58.6 \pm 8.2(stat) \pm 11.3(syst) \pm 6.4(lumi)$	$69.0 \pm 4.6(syst)$
$pp \to e^+e^-\gamma$	$16.4 \pm 4.5(stat) \pm 4.3(syst) \pm 1.8(lumi)$	$13.8 \pm 0.9(syst)$
$pp \to \mu^+\mu^-\gamma$	$10.6 \pm 2.6(stat) \pm 2.5(syst) \pm 1.2(lumi)$	$13.8 \pm 0.9(syst)$





Jet


ATLAS
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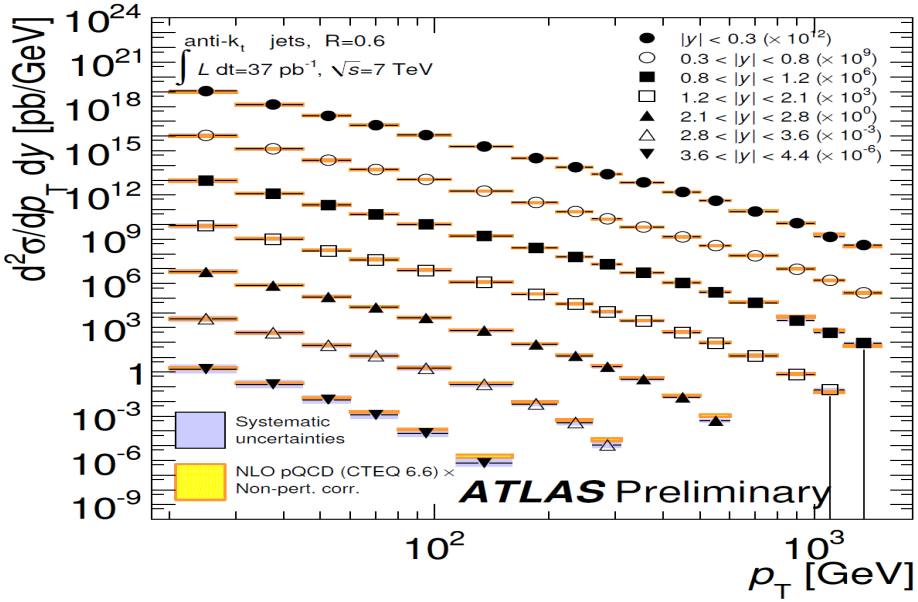
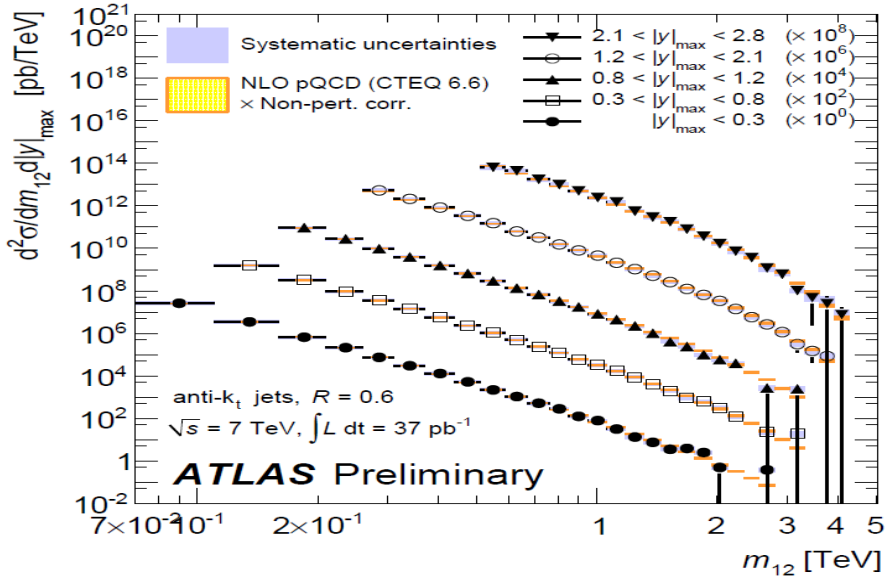
Run Number: 166198, Event Number: 100726931
Date: 2010-10-05 03:27:52 CEST

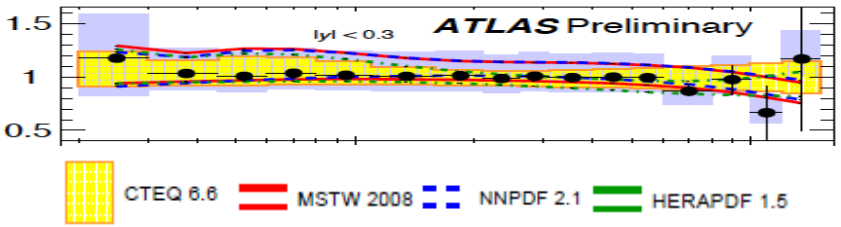
Jet Cross Section

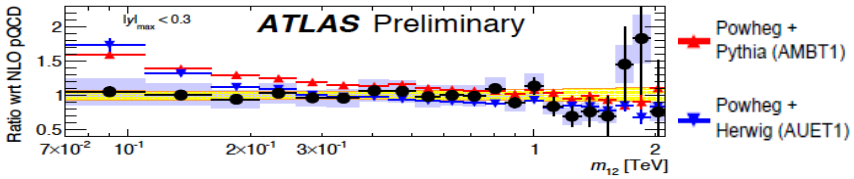
ATLAS-CONF-2011-047

- Measurement of inclusive jet and dijet cross section
- Probing large kinematic region
- Expanding to very forward region |y| up to 4.4
- Excellent agreement with NLO pQCD
- POWHEG comparisons for results





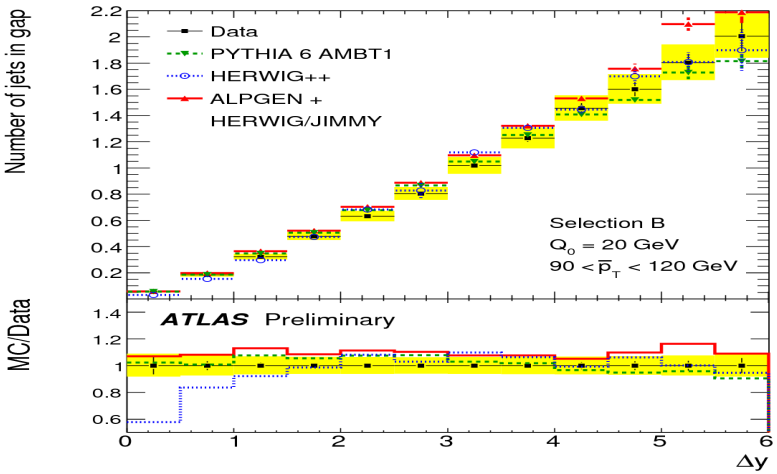




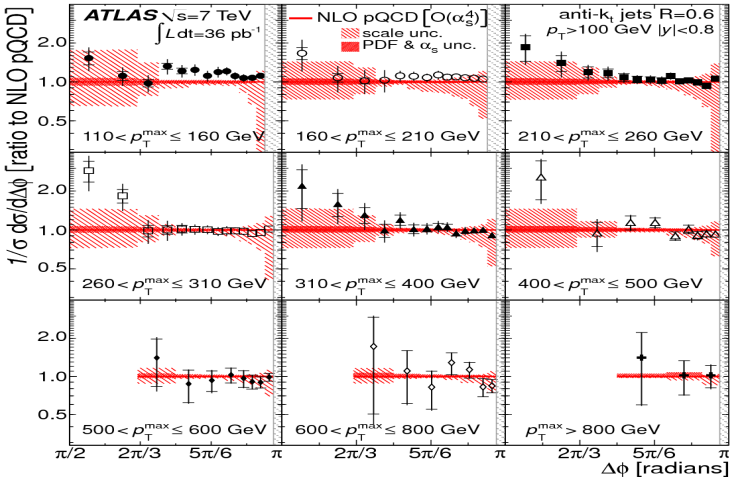
Other Jet Results

ATLAS-CONF-2011-038 arXiv:1102.2696
ATLAS-CONF-2011-056 ATLAS-CONF-2011-043

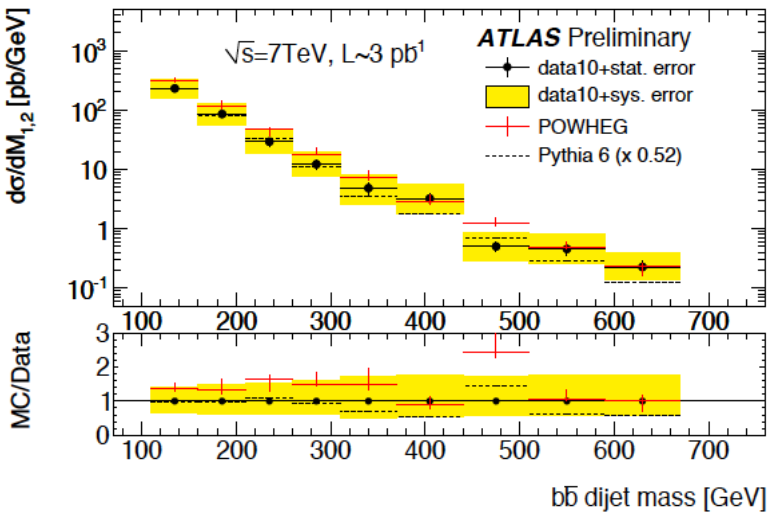
Dijet production with a jet veto



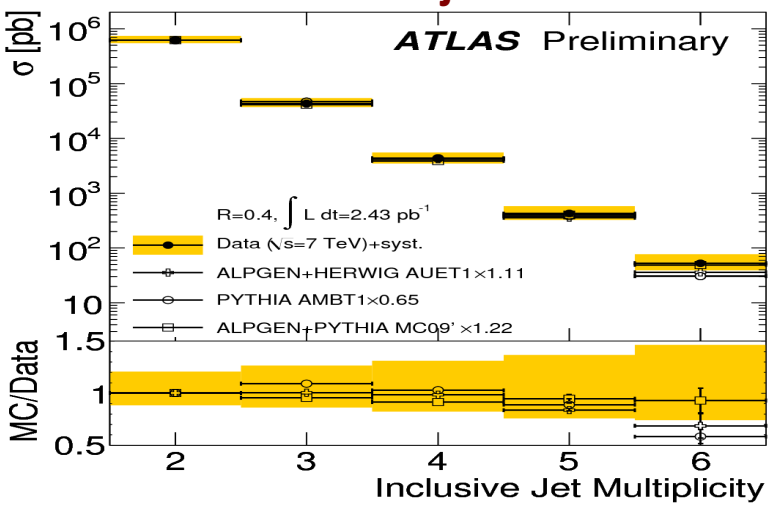
Dijet azimuthal decorrelations



b-jets

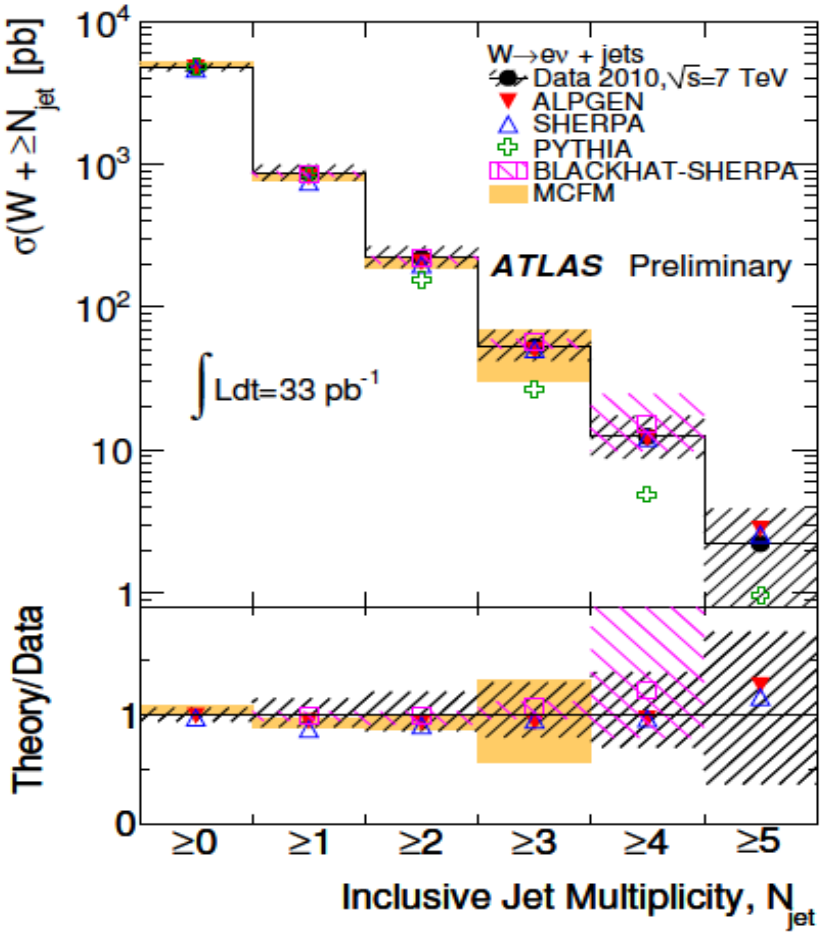


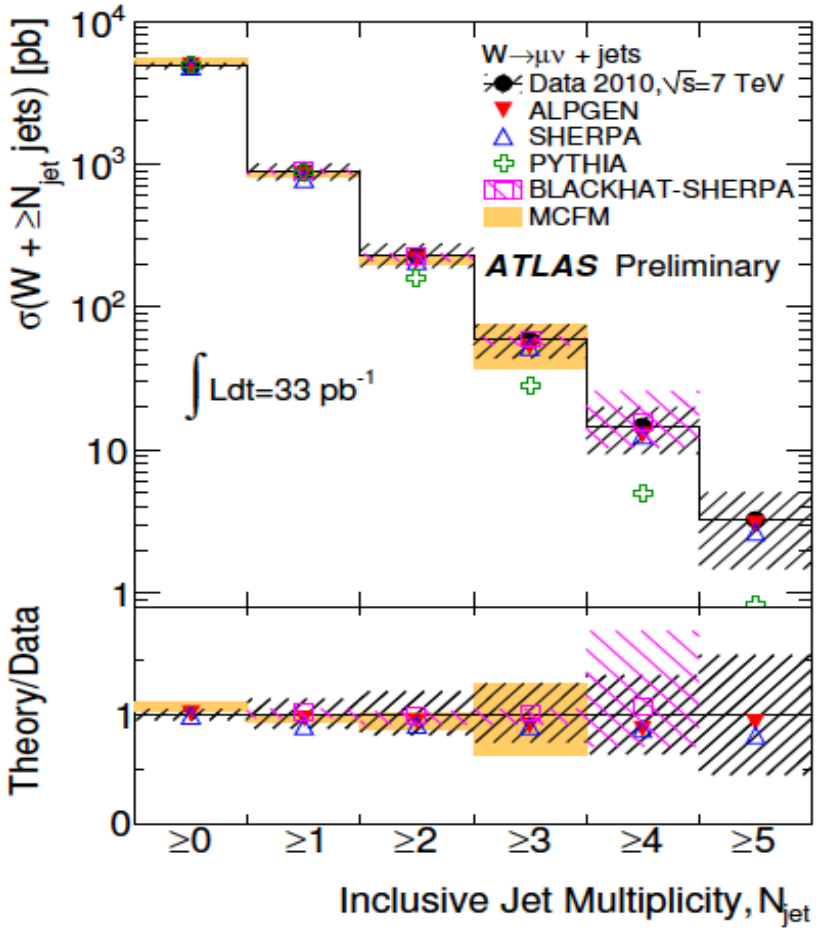
Multijets



W + jets

- W+jets first comparisons with NLO BlackHat prediction (N≤3)
- Major background for top physics, Higgs, SUSY

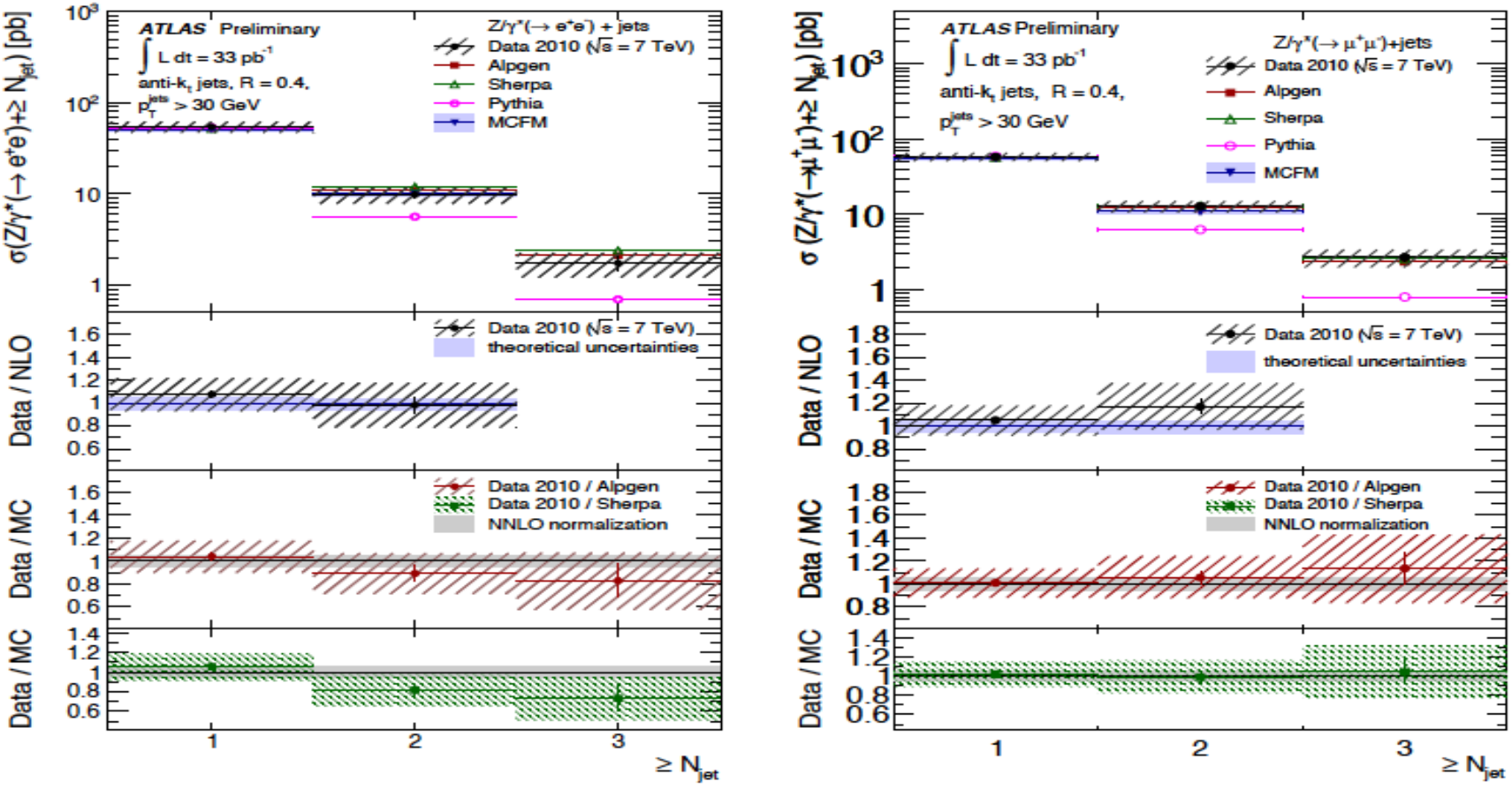




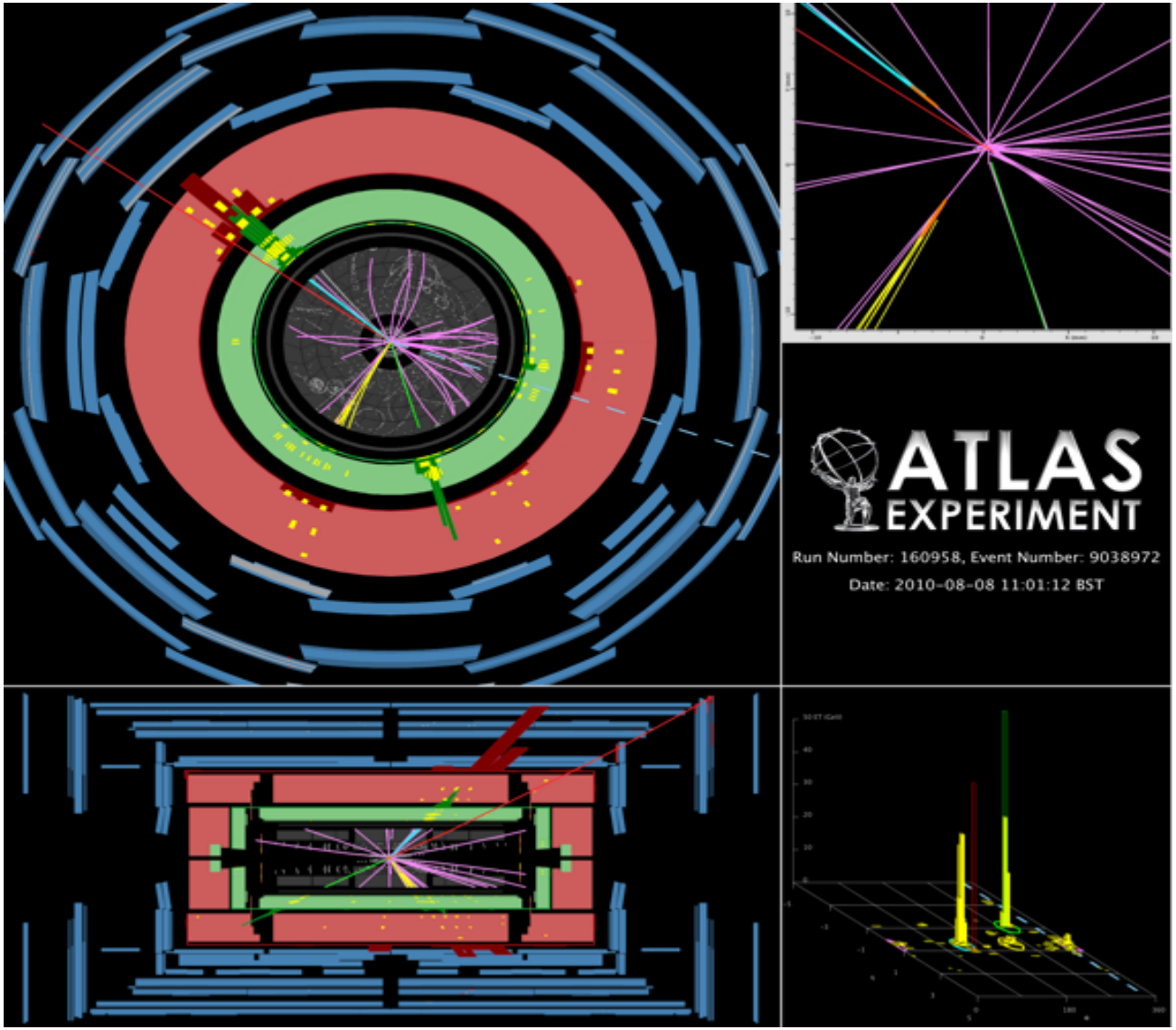
Z + jets

ATLAS-CONF-2011-042

- Z+jets poor agreement with 2→2 Pythia for Njet > 1, good agreement with Alpgen/Sherpa, NLO with MCFM(N≤2)
- Major background for top physics, Higgs, SUSY



Top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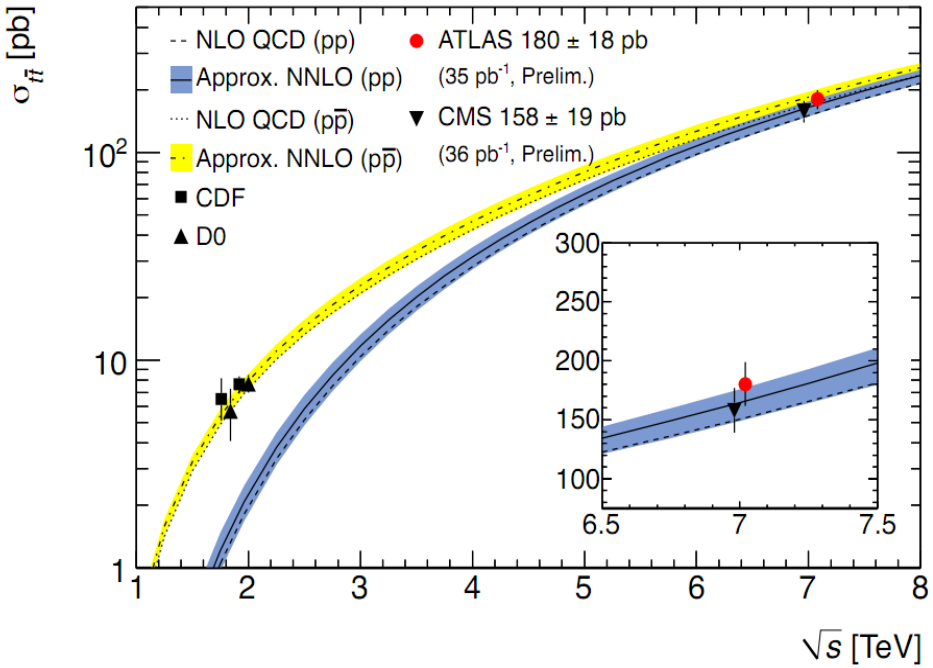
Run Number: 160958, Event Number: 9038972
Date: 2010-08-08 11:01:12 BST

Top Cross Section

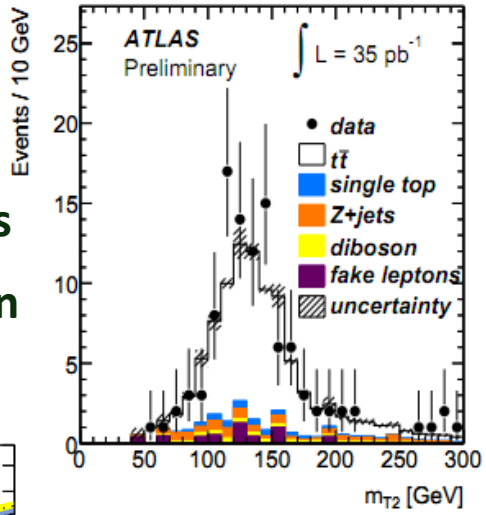
ATLAS-CONF-2011-040 ATLAS-CONF-2011-034
ATLAS-CONF-2011-035

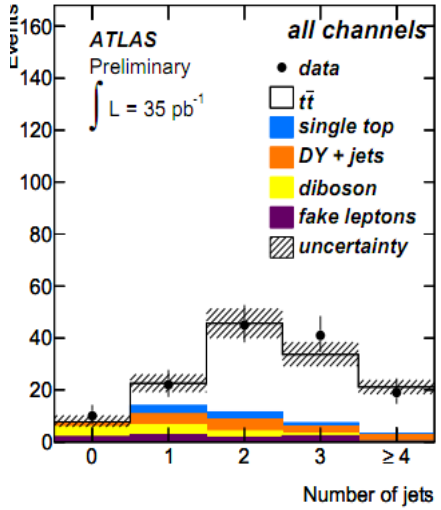
$$\sigma_{t\bar{t}} = 180 \pm 9\ (\text{stat.}) \pm 15\ (\text{syst.}) \pm 6\ (\text{lumi.})\ \text{pb}$$

- Combing lepton+jets, dilepton channels
- Excellent agreement with SM prediction

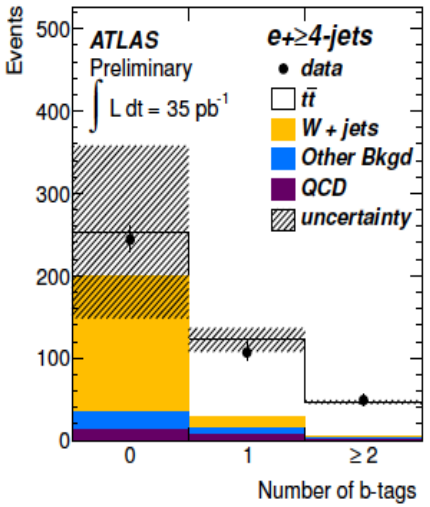


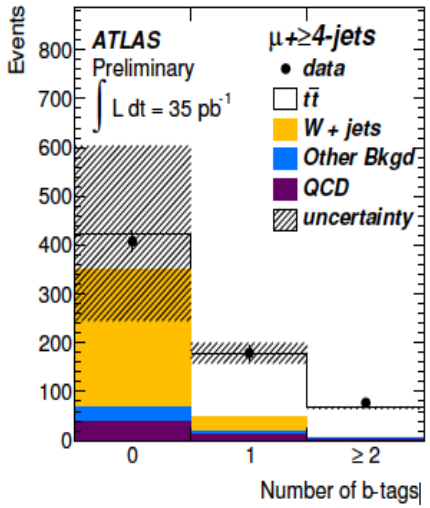
Dilepton



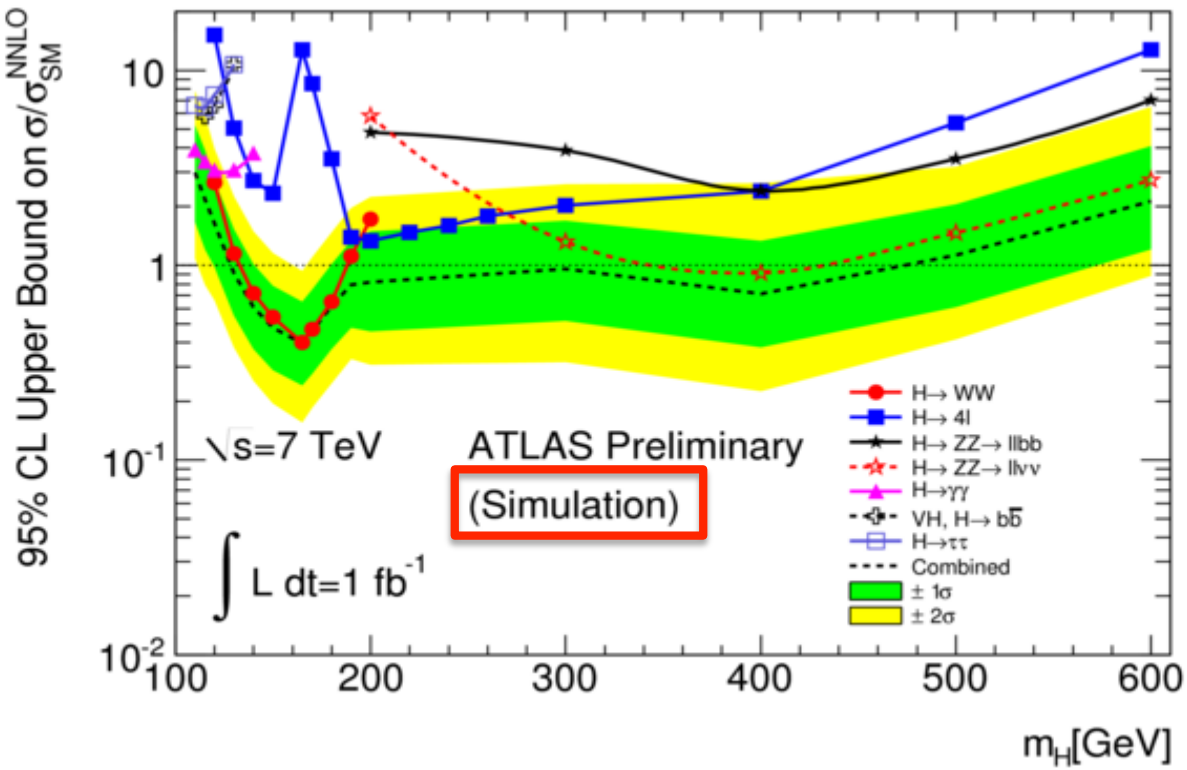


Tagged lepton+jets





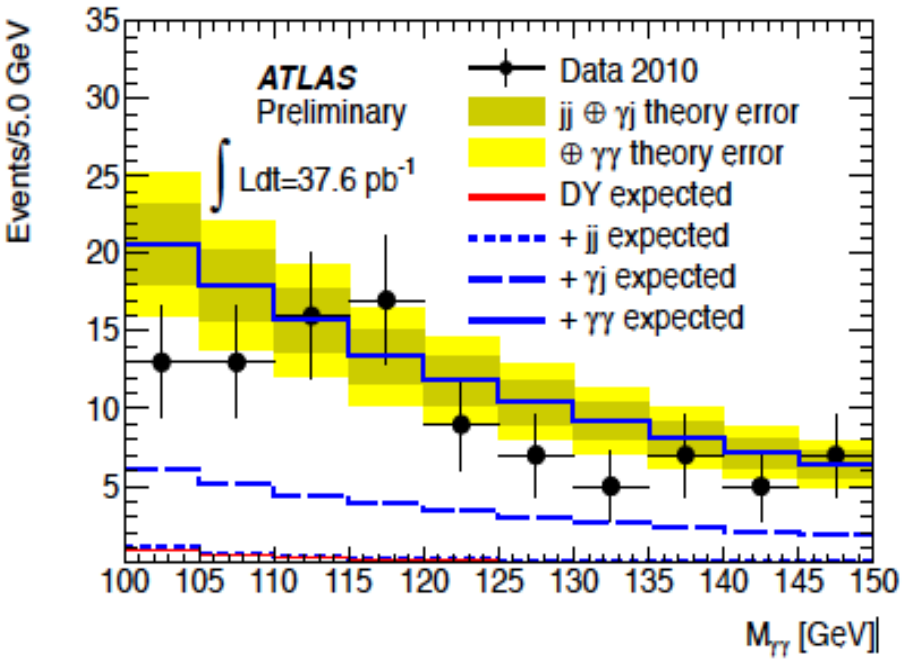
Higgs Search

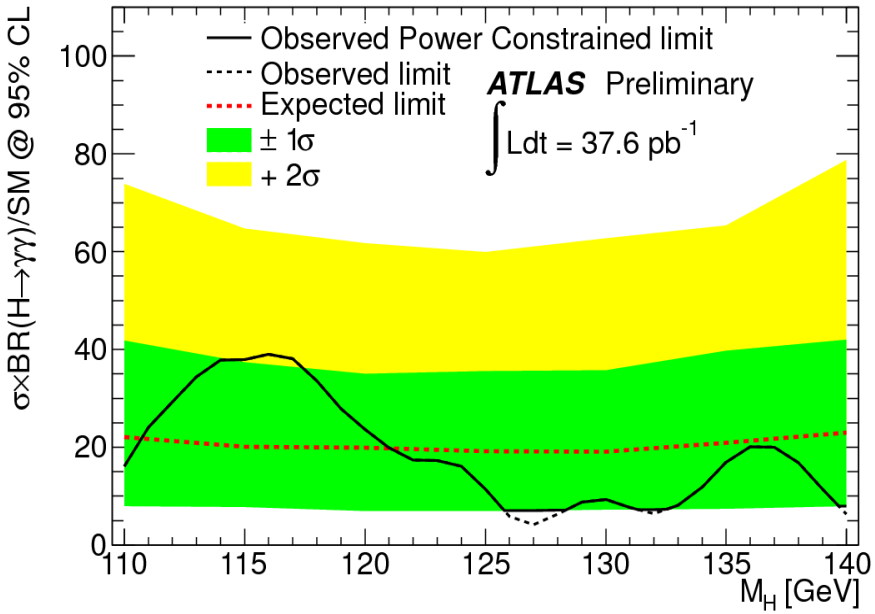


H→γγ

ATLAS-CONF-2011-025

- Mass range 110 GeV - 140 GeV
- Exclusion limit from 8 × SM at m_H = 127 GeV to 38× SM at m_H = 116 GeV





Sensitivity close to the current Tevatron limits

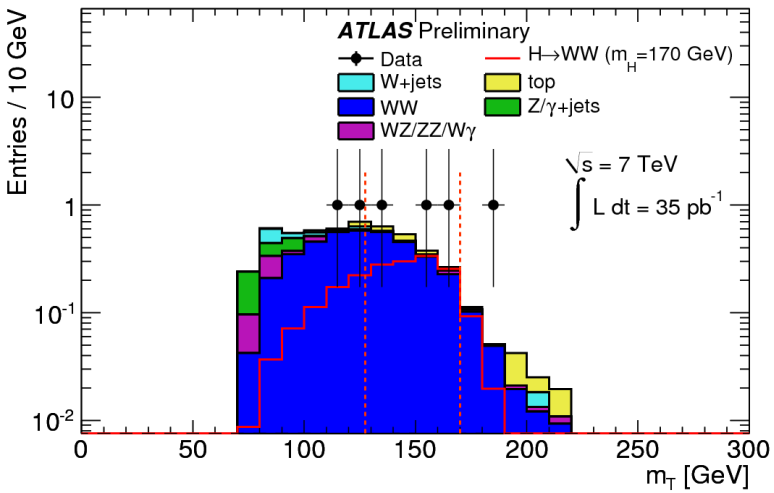
H→WW*→lνlν

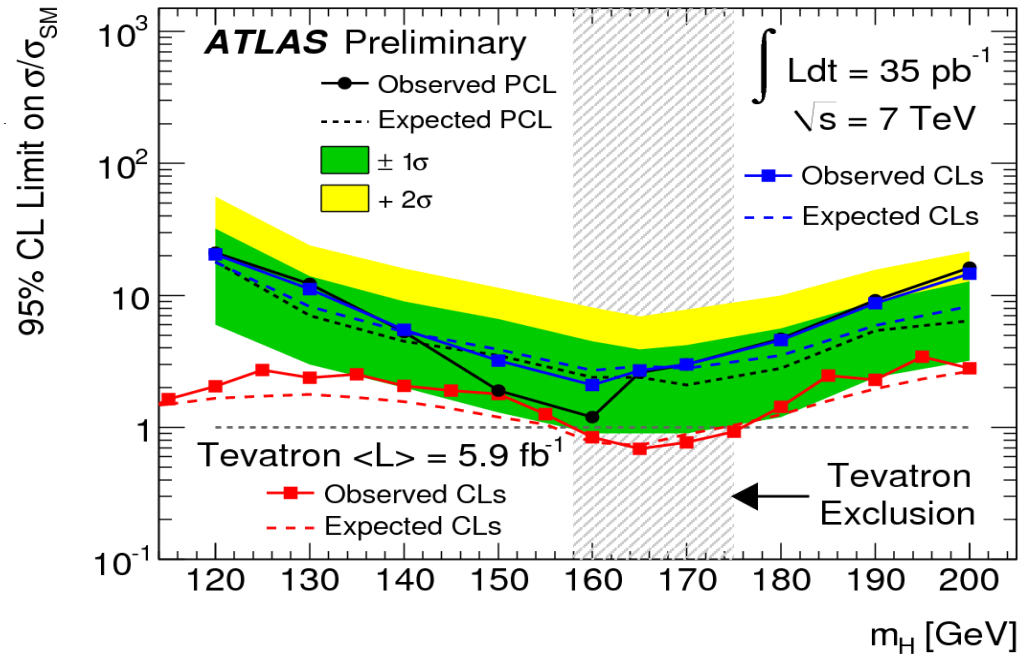
ATLAS-CONF-2011-005

- Mass range 120 - 200 GeV
- No evidence for SM Higgs
- Exclusion limit of 1.2 × SM at m_H = 160 GeV

95% C.L. upper limit of σ×Br(H→WW*)

- m_H=120 GeV : 54 pb
- m_H=160 GeV : 11 pb
- m_H=200 GeV : 71 pb



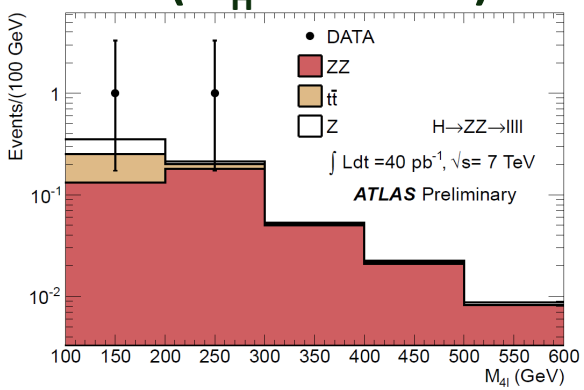


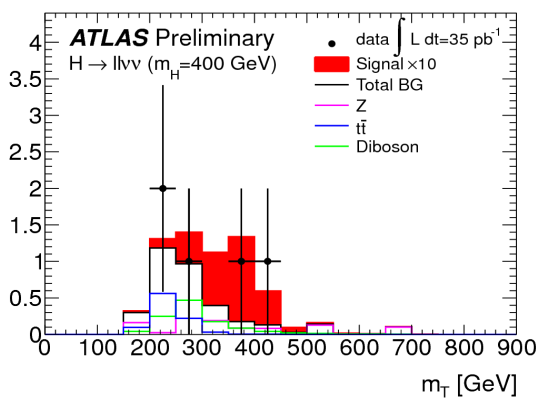
H→ZZ→4l, llνν, llqq

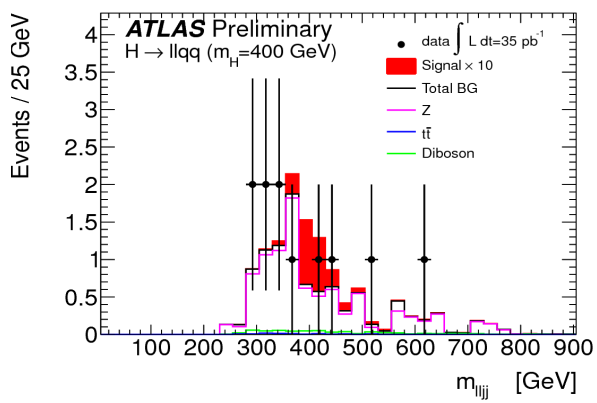
ATLAS-CONF-2011-048

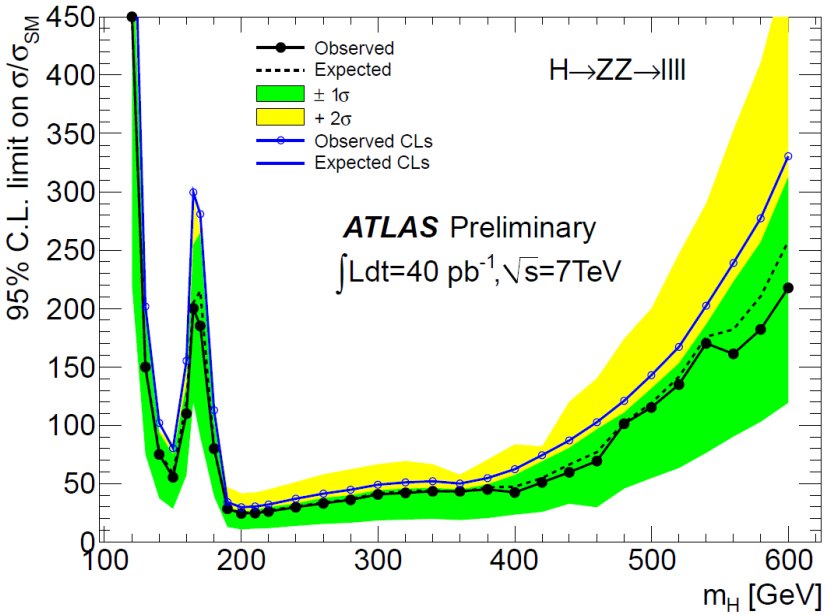
ATLAS-CONF-2011-026

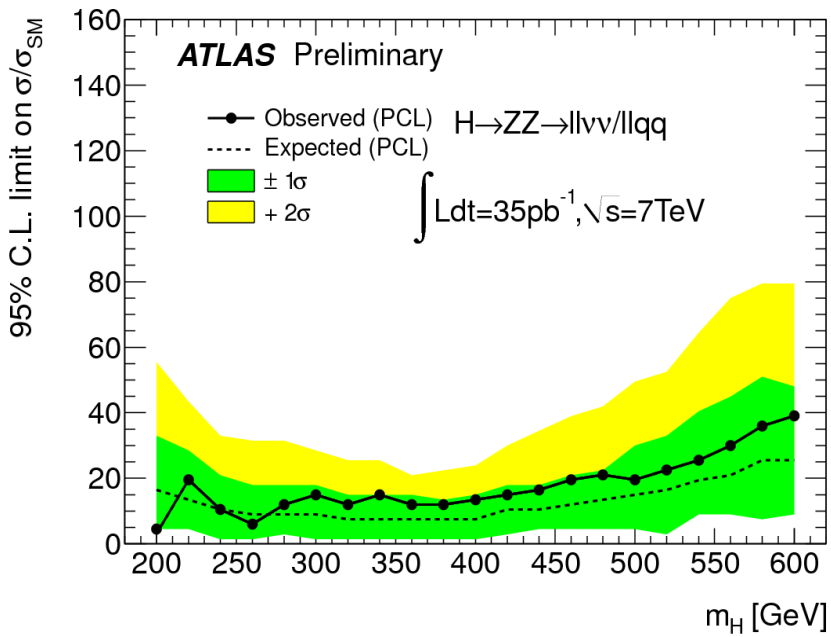
- 4l cross section upper limit of 24 × SM at m_H=200 GeV
- llνν/llqq cross section upper limit from 3.5 × SM (m_H=200 GeV) to 39.0 × SM (m_H=600 GeV)









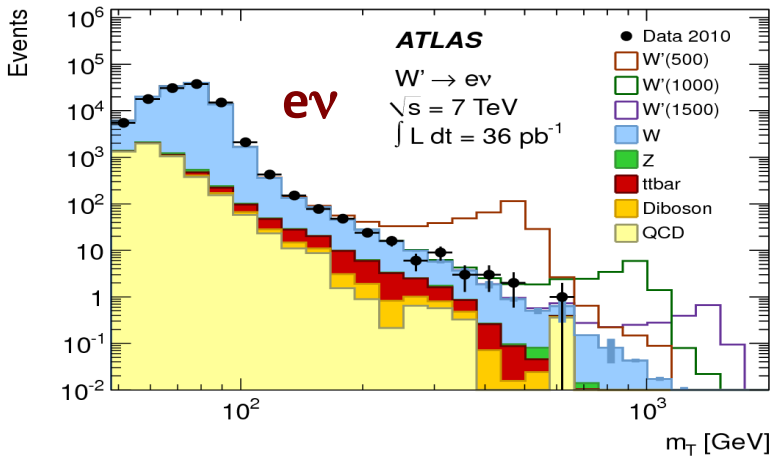


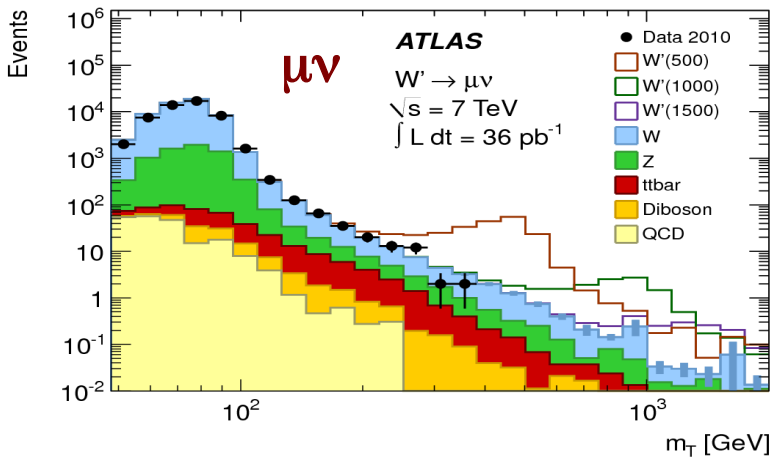
Searches for New Physics

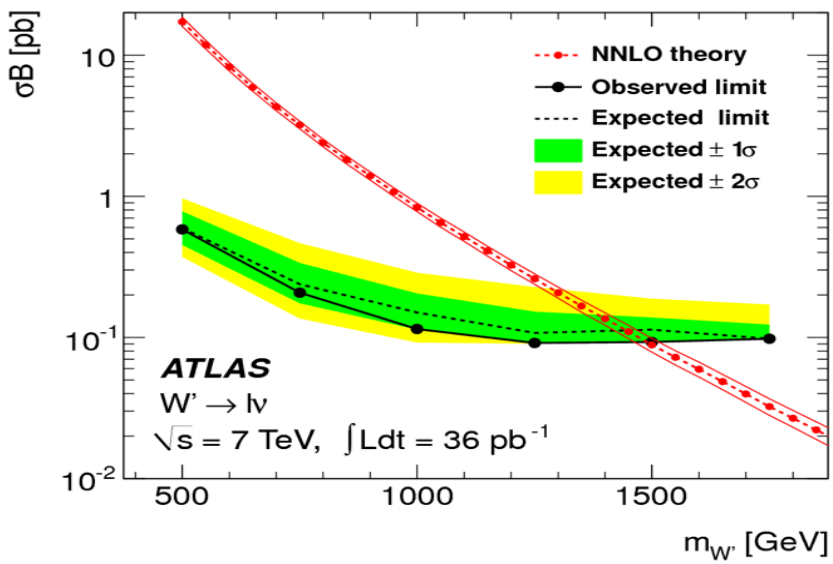
Exotics, SUSY

Extra Gauge Boson W'

arXiv:1103.1391







95% C.L. limit

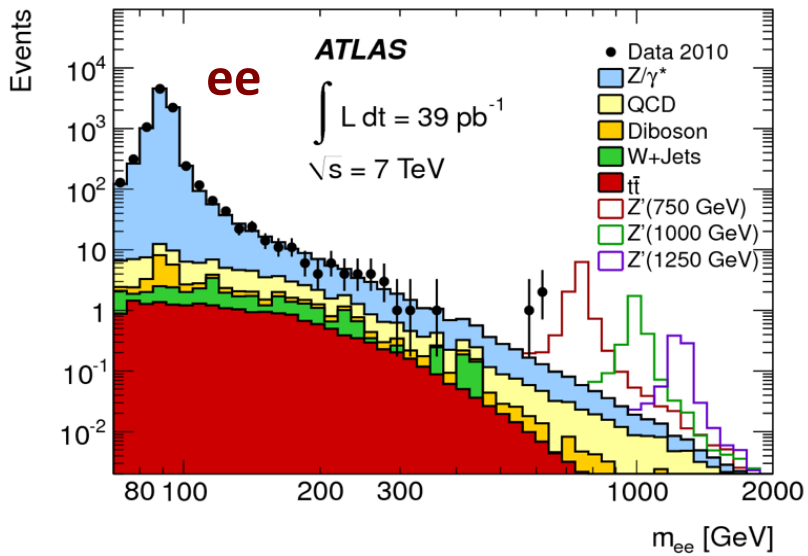
$M_{W'}$ > 1.49 TeV (1.45 expected)

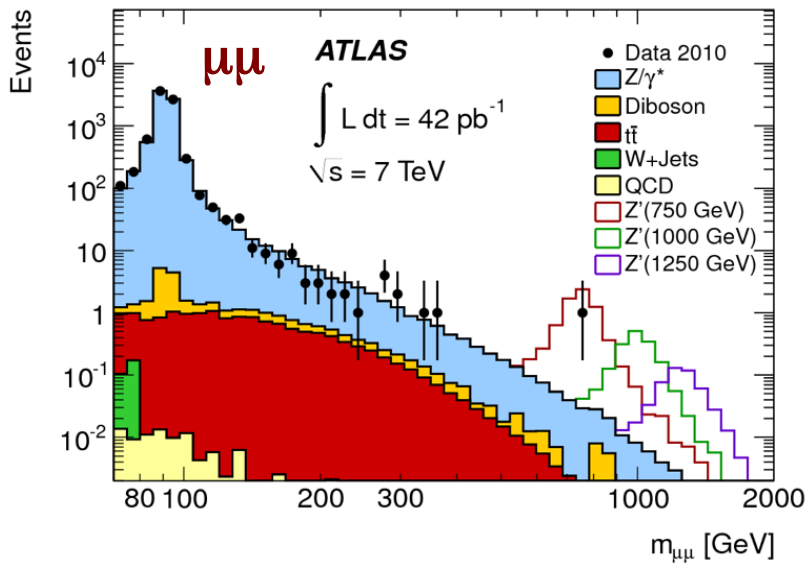
(Tevatron Limit 1.12 TeV)

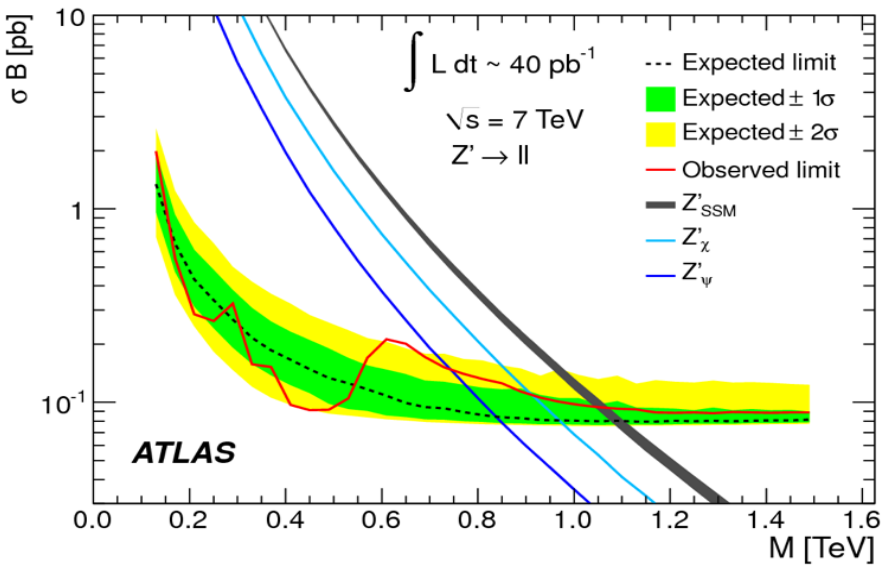
Limit also for W*

Extra Gauge Boson Z'

arXiv:1103.6218







95% C.L. Limit Observed (Expected)

$M(Z'_{SSM}) > 1.048\ (1.084)$ TeV

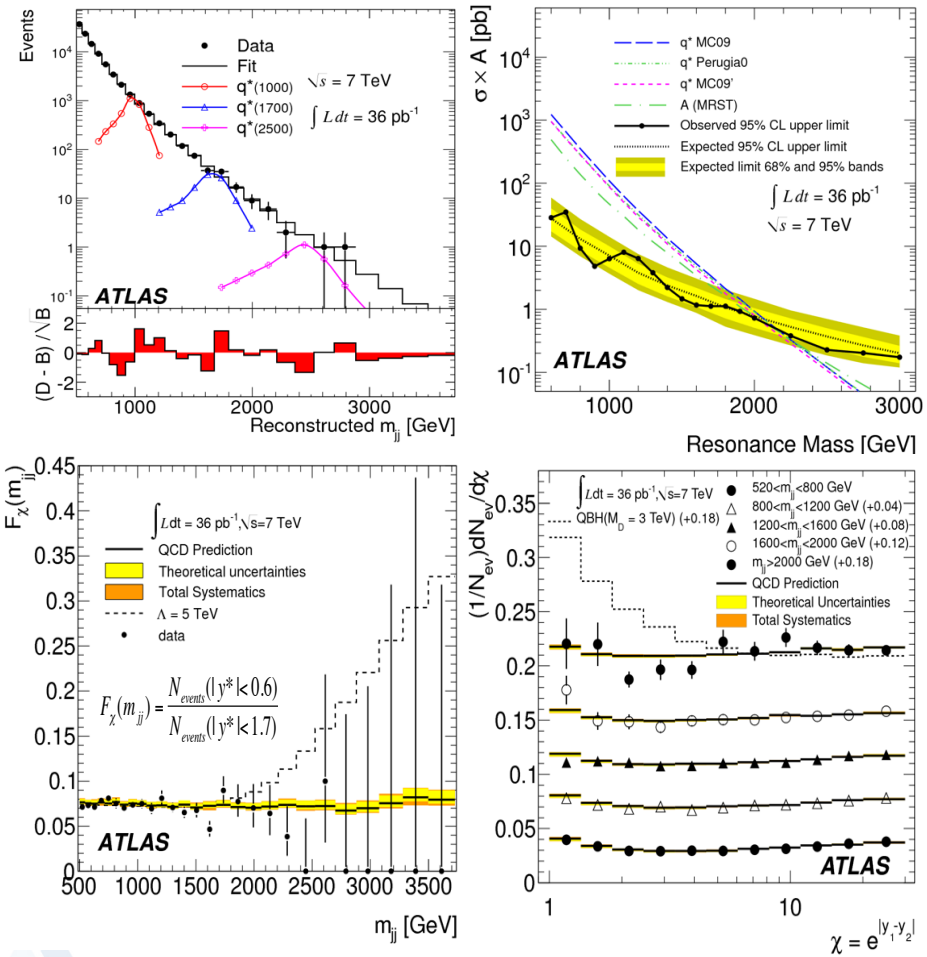
(Tevatron Limit 1.071 TeV)

Limits also for Z* and E6 Z'

Dijet Exotics

arXiv:1103.3864

- **Excited quark, quantum blackhole, axigluon, contact interaction Λ …**
- **Combining resonance and angular search**



Model and Analysis Strategy	95% C.L. Limits (TeV) Expected	Observed
Excited Quark q^*		
Resonance in m_{jj}	2.07	2.15
$F_\chi(m_{jj})$	**2.12**	**2.64**
Randall-Meade Quantum Black Hole for $n = 6$		
Resonance in m_{jj}	**3.64**	**3.67**
$F_\chi(m_{jj})$	3.49	3.78
θ_{np} Parameter for $m_{jj} > 2$ TeV	3.37	3.69
11-bin χ Distribution for $m_{jj} > 2$ TeV	3.36	3.49
Axigluon		
Resonance in m_{jj}	**2.01**	**2.10**
Contact Interaction Λ		
$F_\chi(m_{jj})$	**5.7**	**9.5**
F_χ for $m_{jj} > 2$ TeV	5.2	6.8
11-bin χ Distribution for $m_{jj} > 2$ TeV	5.4	6.6

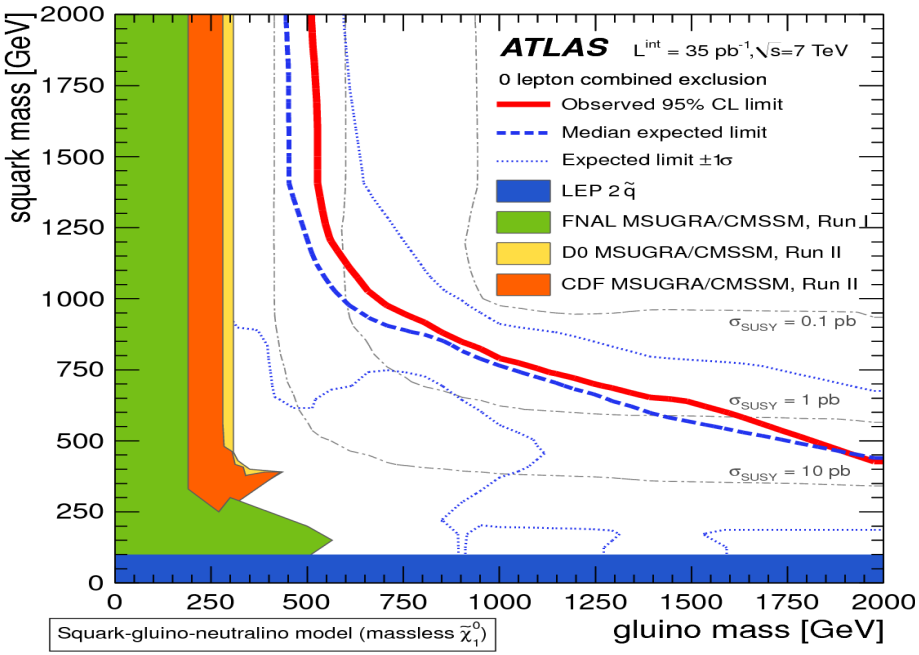
	Tevatron
Q*	M > 0.87 TeV
Axigluon	M > 1.25 TeV
Contact Interaction Λ	Λ > 2.84-3.06 (2.76-2.91) TeV

SUSY: Jets (b-jets) + E_T^{miss}

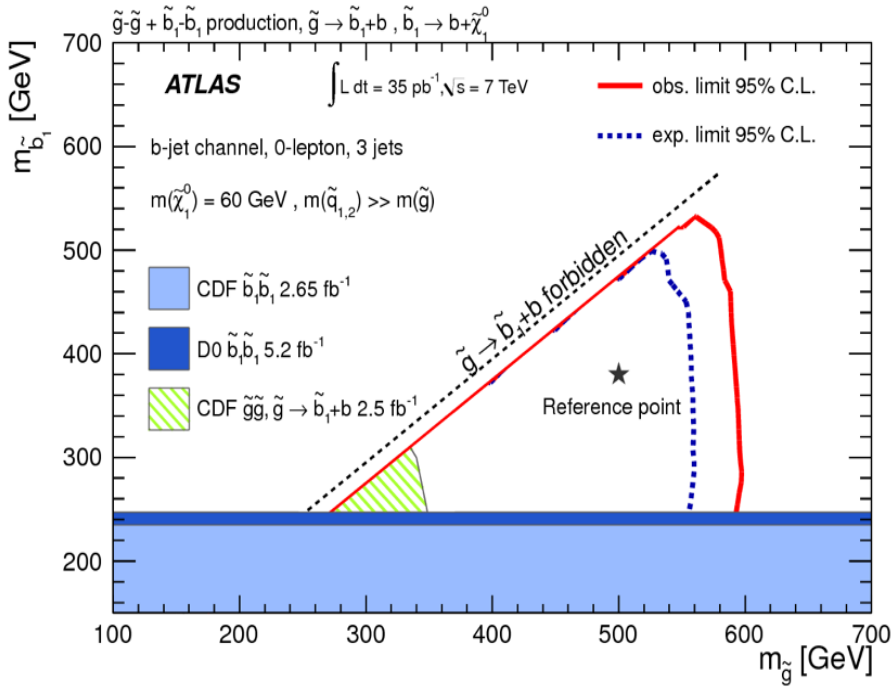
arXiv:1102.5290

arXiv:1103.4344

- Jets and large E_T^{miss}
- No excess seen
- Interpretation in phenomenological simplified MSSM
- Also interpretation in mSUGRA



- ≥1 b-jets and large E_T^{miss}
- No excess seen
- Interpretation in R parity conserving models
- Also interpretation in mSUGRA



Currently most stringent limits

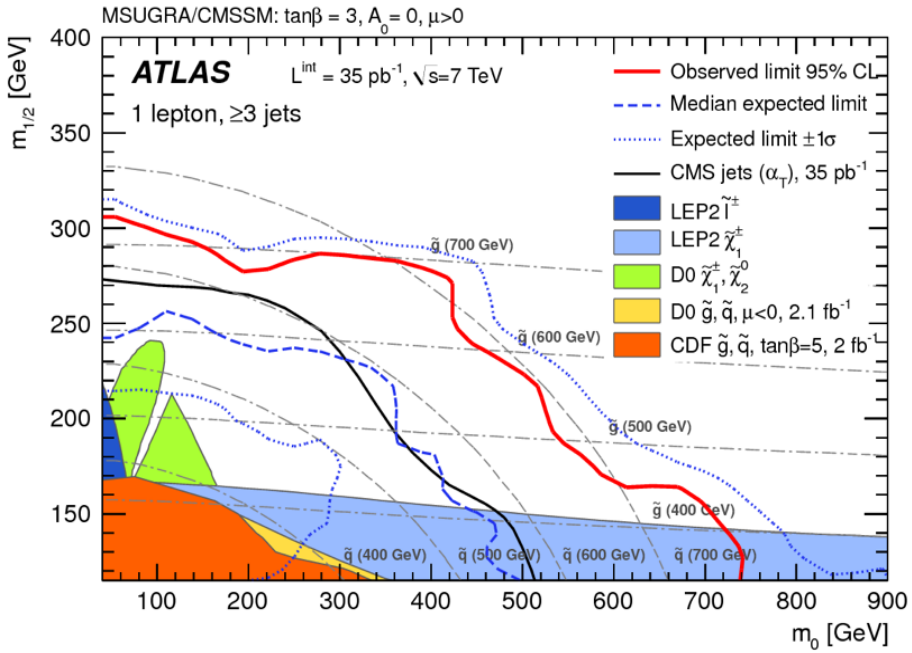
Limits beyond Tevatron results

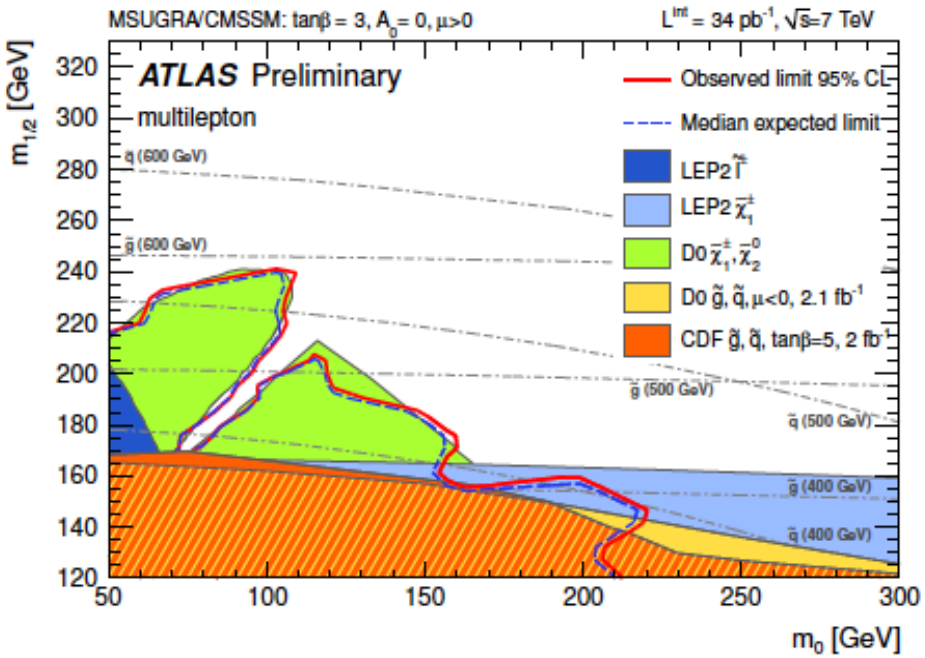
SUSY: Lepton(s) + Jets + E_T^{miss}

- Isolated lepton(s), jets and moderate E_T^{miss}
- 1 lepton or multi leptons
- No excess seen
- Interpretation in mSUGRA

arXiv:1102.2357

ATLAS-CONF-2011-039





Limits beyond LEP and Tevatron results for the 1 lepton final state

Limits similar to Tevatron results for the multi lepton final state

Conclusions

- ATLAS Detector operating well
- Starting precision measurements of the Standard Model
- Reaching unprecedented sensitivity in several channels, and catching up soon in the others
- Ready to discover new physics, stay tuned

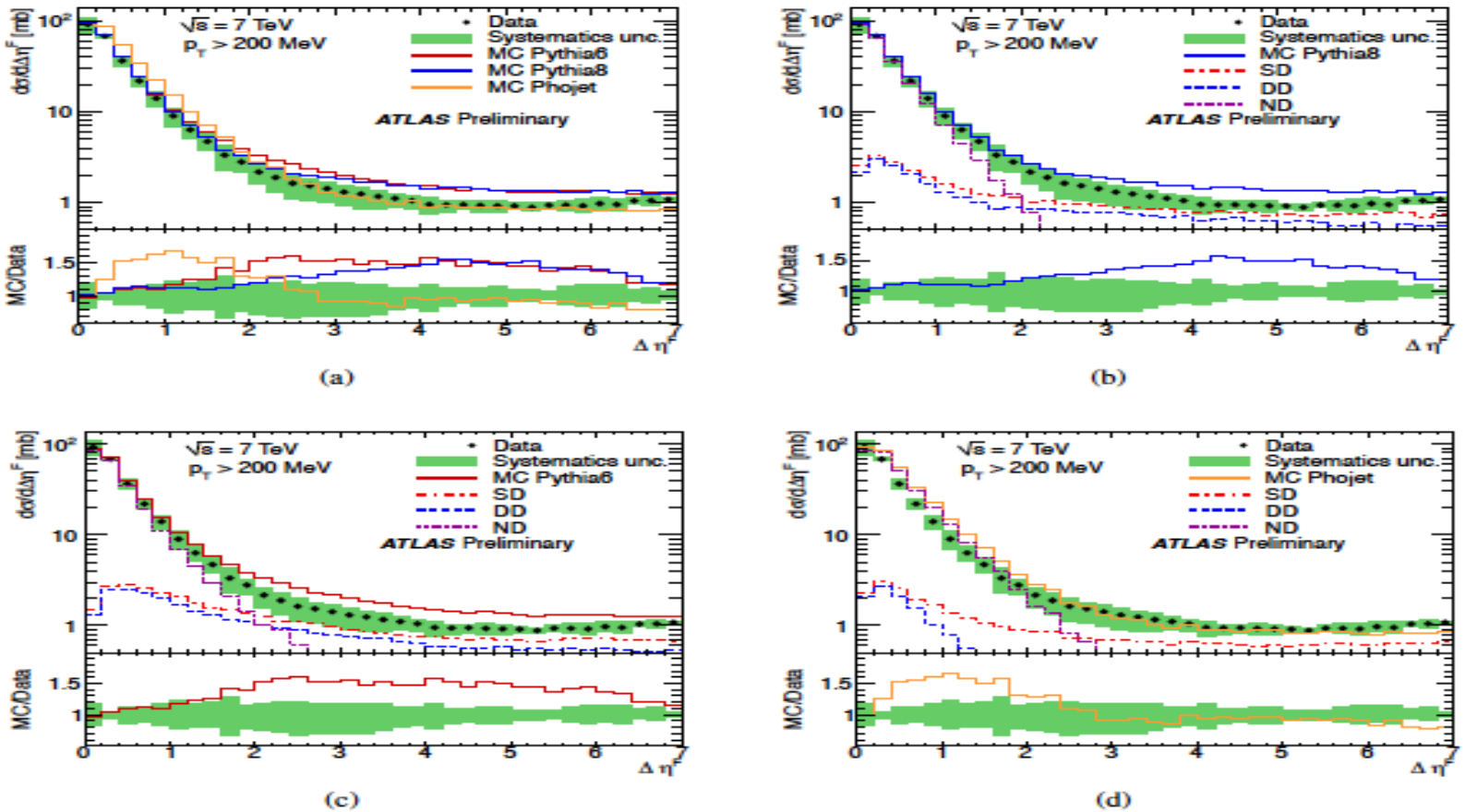
Roadmap

ATLAS Speaker	Topic included	Session
Gabriella Pasztor	Vector-Meson production	WG2 PS10
Lauren Tompkins	Inelastic cross section	WG2 PS8
Holger Schulz	MB & UE	WG4 PS5
Giovanni Marchiori	Prompt photon	WG4 PS7
Renat Ishmukhametov	Direct photon	WG1 PS3
Gabriele Chiodini	Exclusive heavy flavour production	WG5 PS1
Frank Ellinghaus	W and Z production	WG3 PS4
Verena Martinez Outschoorn	W and Z cross sections	WG3 PS7
Jianbei Liu	WW production	WG3 PS8
Andrea Bocci	W/Z+photon production	WG3 PS8
Joaquin Poveda	jet cross sections	WG4 PS1
Long Zhao	Dijet and Multijet cross sections	WG4 PS9
Aranzazu Ruiz-Martinez	Inclusive bbbar production	WG5 PS1
Dag Ingemar Gillberg	Small-x and forward measurements	WG2 PS3
Stefan Ask	W/Z + jets	WG4 PS8
Yasuyuki Okumura	Top cross section	WG5 PS8
Nicolas Moeser	Higgs	WG3 PS1
Tatjana Lenz	Searches for BSM	WG3 PS10
Shikma Bressler	SUSY	WG3 PS2
Manuel Kayl	Diffractive measurements	WG2 PS5
Miguel Fiolhais	Top quark mass and properties	WG5 PS9
Dominique Tardif	Single top production	WG5 PS9
Cristina Oropeza Barrera	Particle distributions and correlations	WG4 PS6

Back Up Materials

Soft QCD: Diffraction

- Rapidity gap reconstructed via calorimeter cell energy measurement
- Diffractive cross section component tuned in MC generators with data
- Diffractive cross section measured with $\Delta\eta^F < 7$, to $|\eta| < 4.9$



W Charge Asymmetry

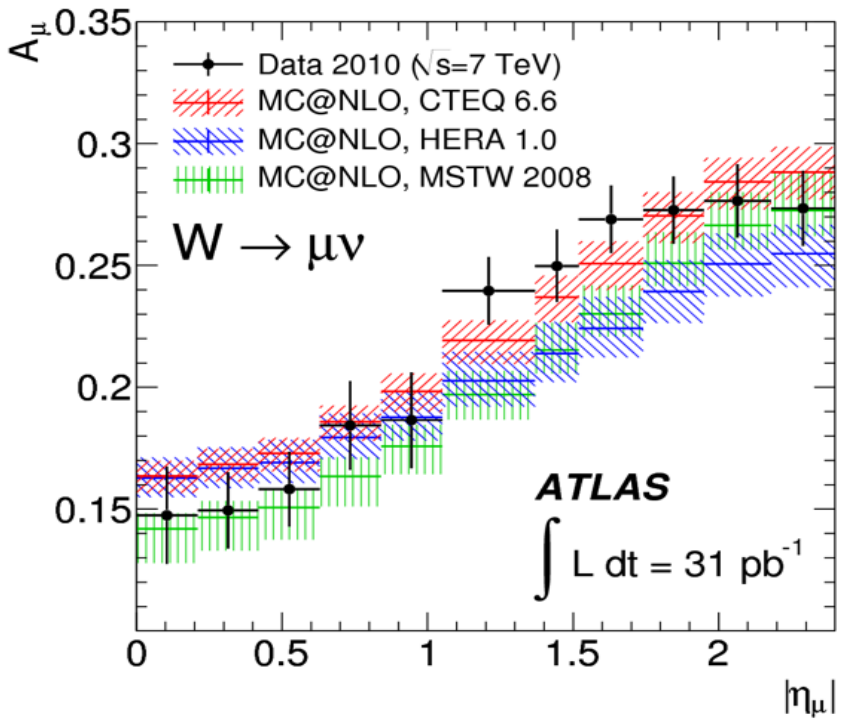
arXiv:1103.2929

$$A_\mu = \frac{d\sigma_{W\mu+}/d\eta_\mu - d\sigma_{W-}/d\eta_\mu}{d\sigma_{W\mu+}/d\eta_\mu + d\sigma_{W-}/d\eta_\mu} \approx \frac{d(x)}{u(x)}$$

- **Constraining PDFs**
- **Understanding QCD in low x**

$10^{-3} \leq x \leq 10^{-1}$

- **No precise measurement of the u/d ratio below x < 0.05 yet**
- **Predictions not fully consistent**

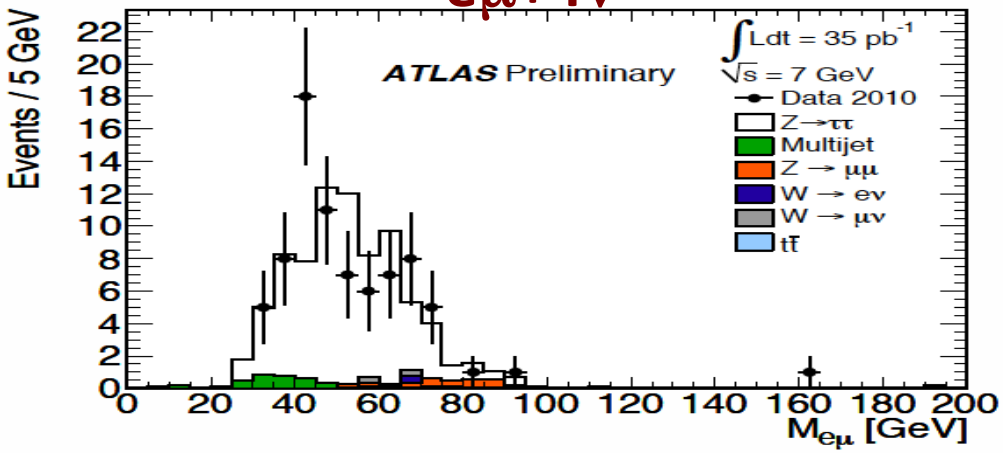


$Z \rightarrow \tau\tau$

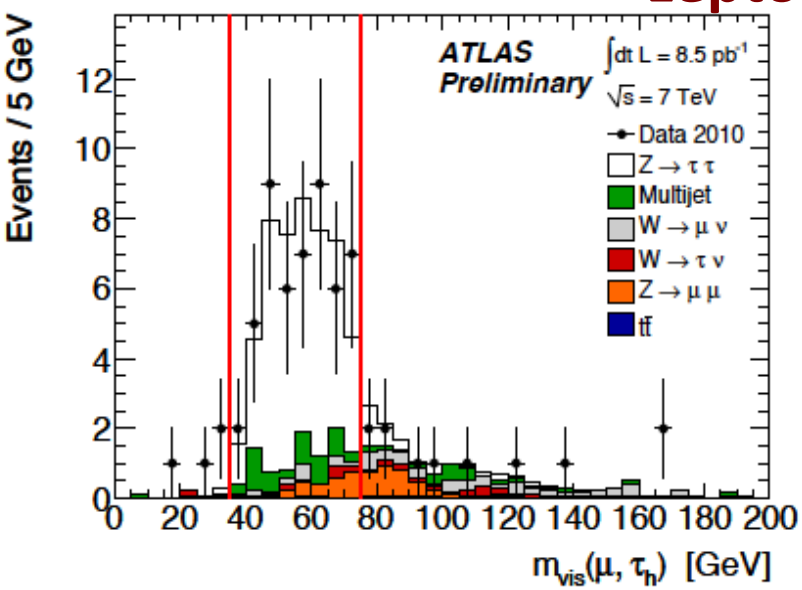
ATLAS-CONF-2011-045

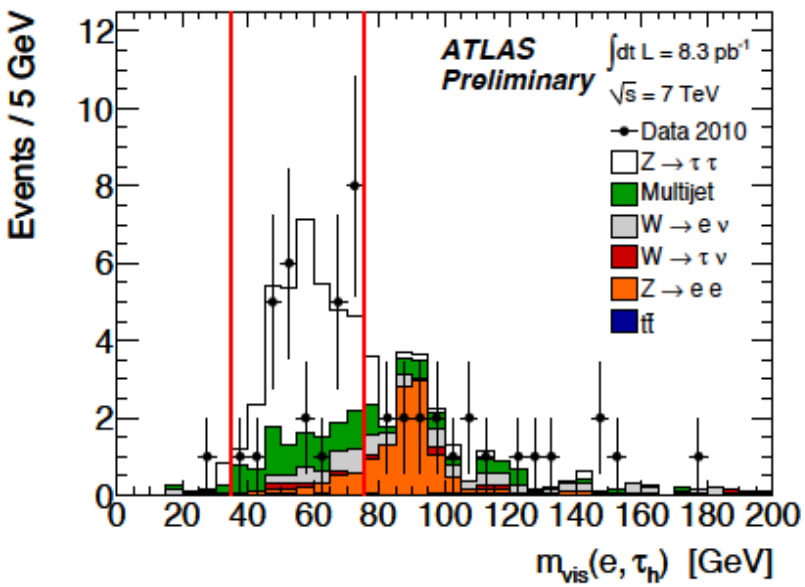
ATLAS-CONF-2011-010

eμ+4ν



Lepton+hadrons





Top Properties

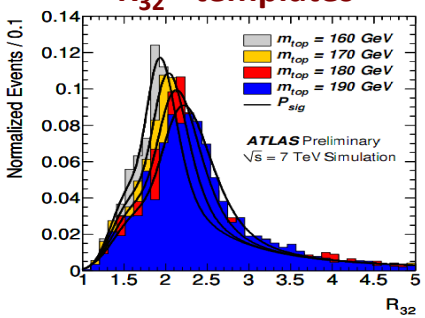
ATLAS-CONF-2011-033

ATLAS-CONF-2011-037

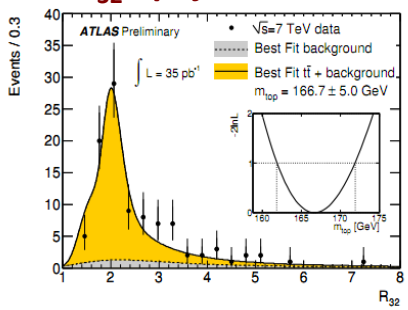
- **Top Mass**
  - Measured in lepton+jets channel
  - Using ratio of reconstructed top to W mass
  - m_t = 169.3 ± 4.0 ± 4.9 GeV

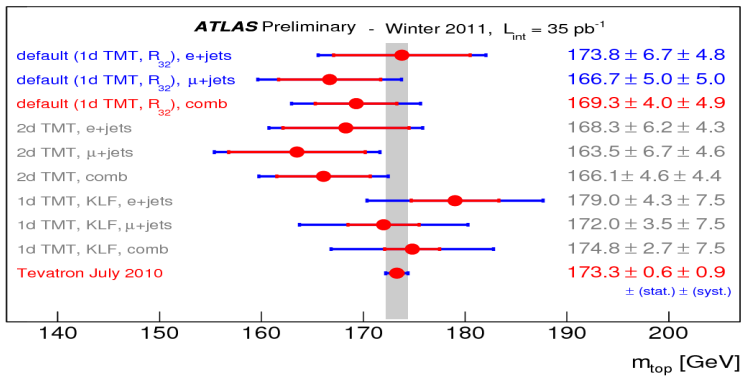
- **W helicity in top decays**
  - Sensitive to anomalous couplings
  - F_L = 0.59 ± 0.12
  - F_0 = 0.41 ± 0.12
  - Approaching Tevatron precision

R_{32} - templates

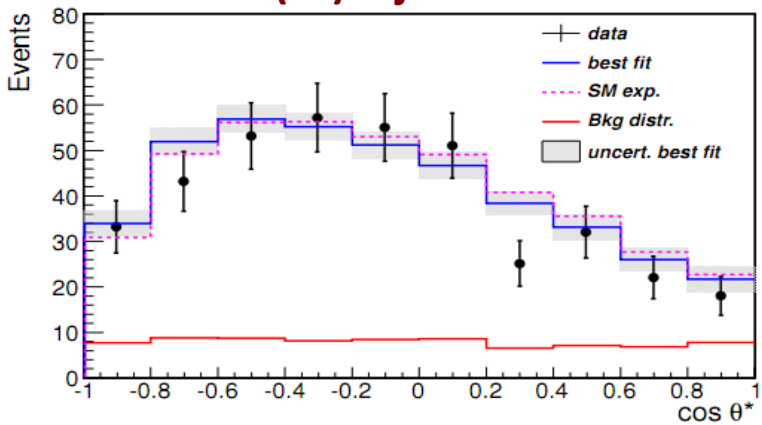


R_{32} - μ+jets channel



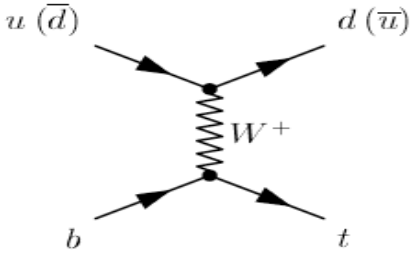


cos(θ*) l+jets channel

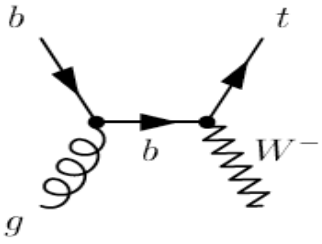


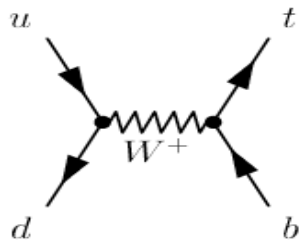
Single Top

ATLAS-CONF-2011-027

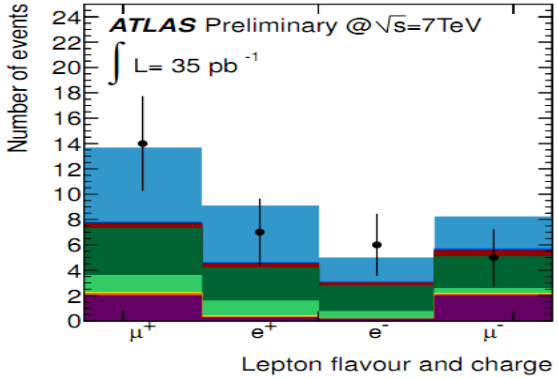


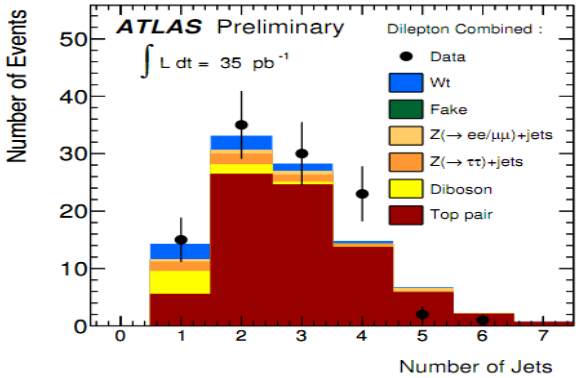
1 lepton+jets





1, 2 lepton+jets

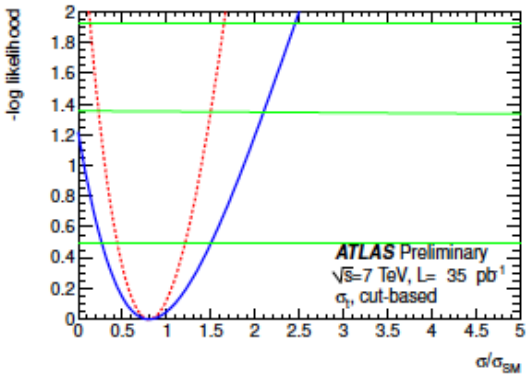


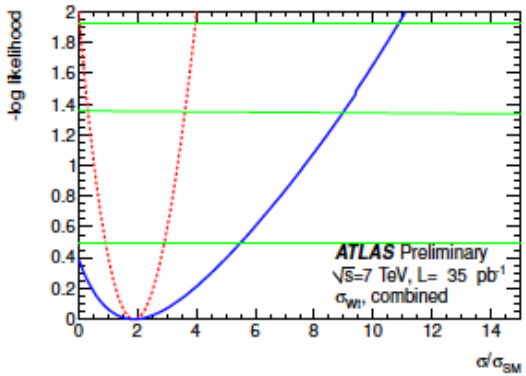


t-channel

SM: ~66 pb

$$\sigma_t < 162 \text{ pb}$$



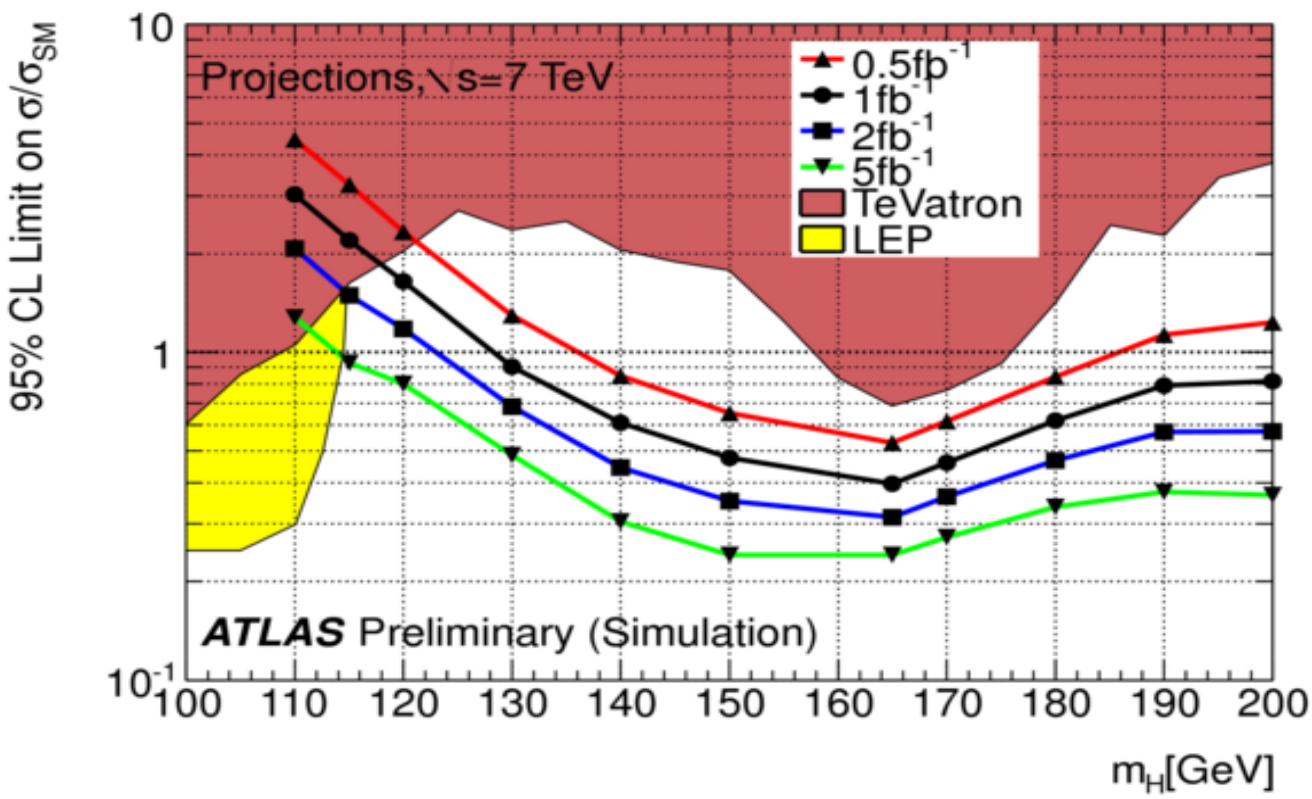


Wt-channel

SM: ~15 pb

$$\sigma_{Wt} < 158 \text{ pb}$$

Higgs Sensitivity

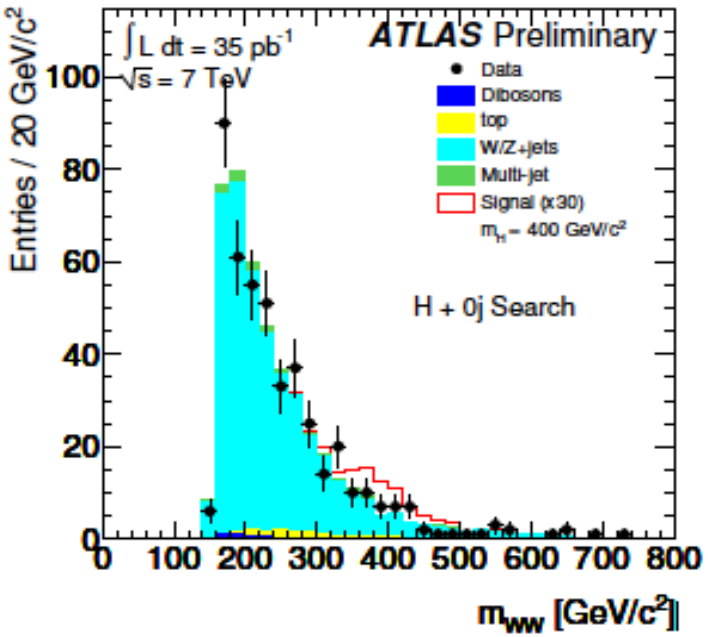


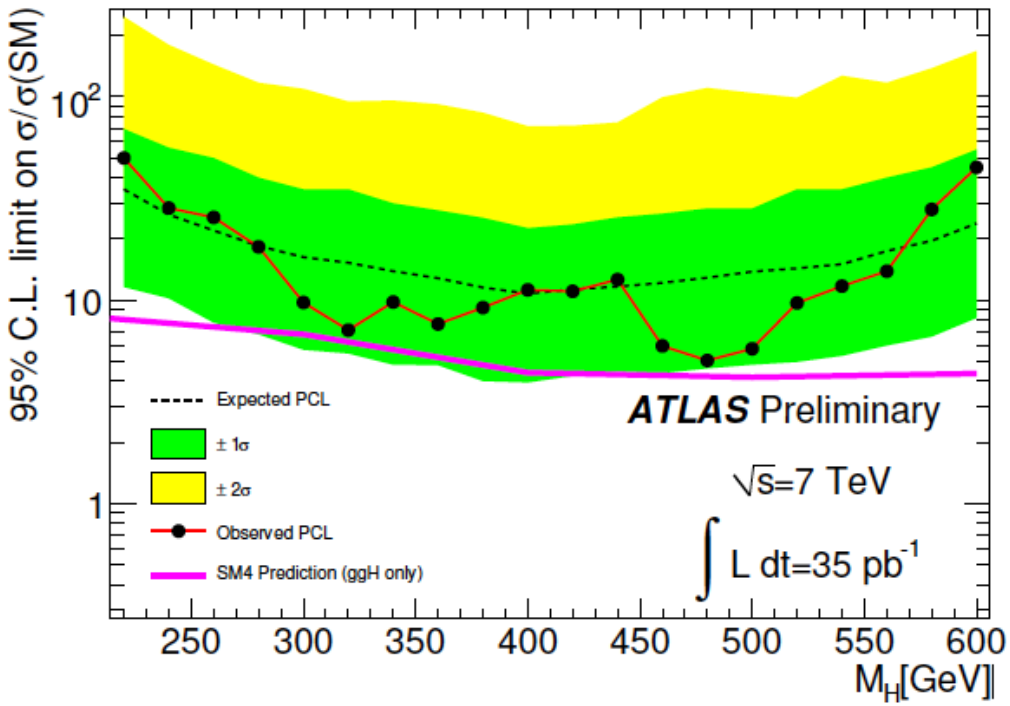
- **5fb^{-1} needed to close gap with LEP at 7 TeV**
- **3σ observation expected from 123 to 550 GeV**

H→WW→lνqq

ATLAS-CONF-2011-052

- Mass range 200 - 600 GeV
- Exclusion limit of 11.2 × SM at m_H = 400 GeV
- Close to SM4 prediction at m_H ~ 320 GeV and m_H ~ 480 GeV

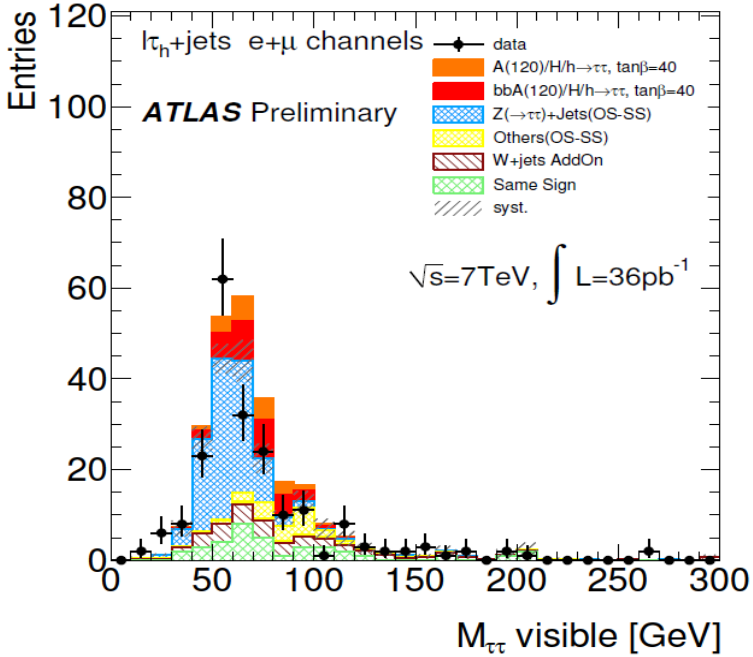


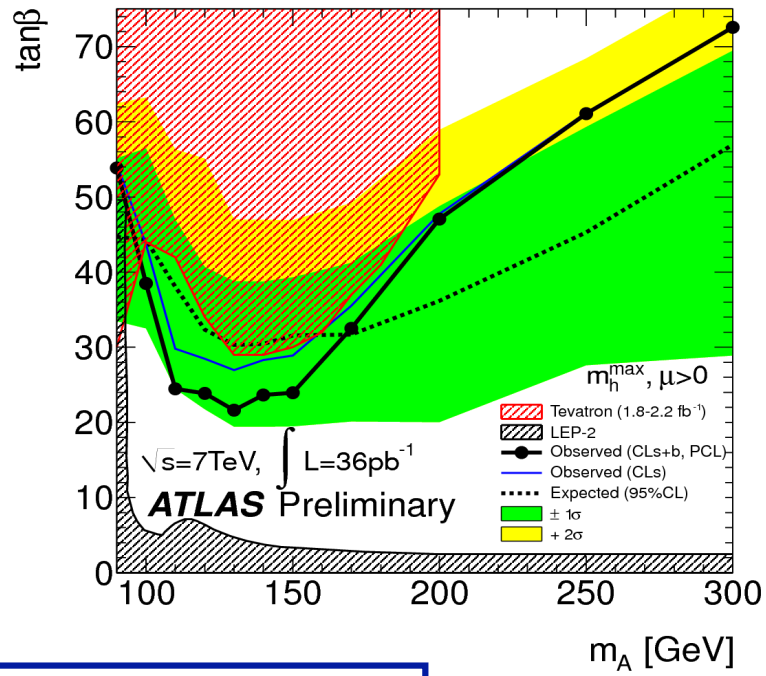


MSSM Neutral A/H/h → $\tau^+ \tau^-$

ATLAS-CONF-2011-024

- Two Higgs doublets required in MSSM
- One τ with leptonic decay and the other with hadronic
- Exclusion limit as function of the parameters m_A and tanβ



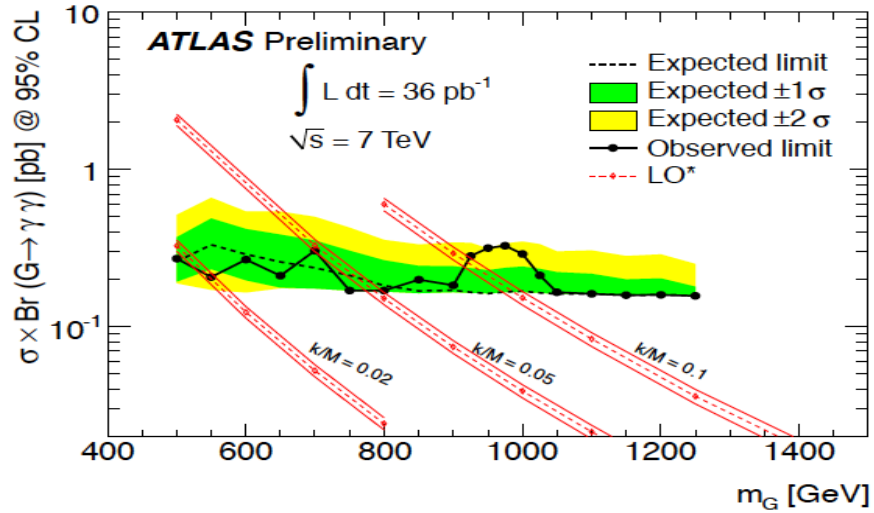


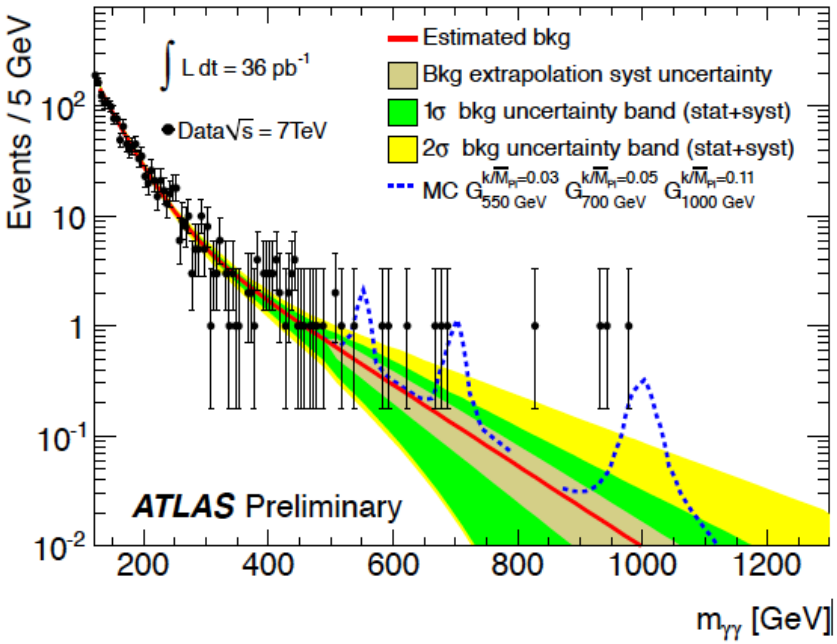
Exclusion reach beyond Tevatron

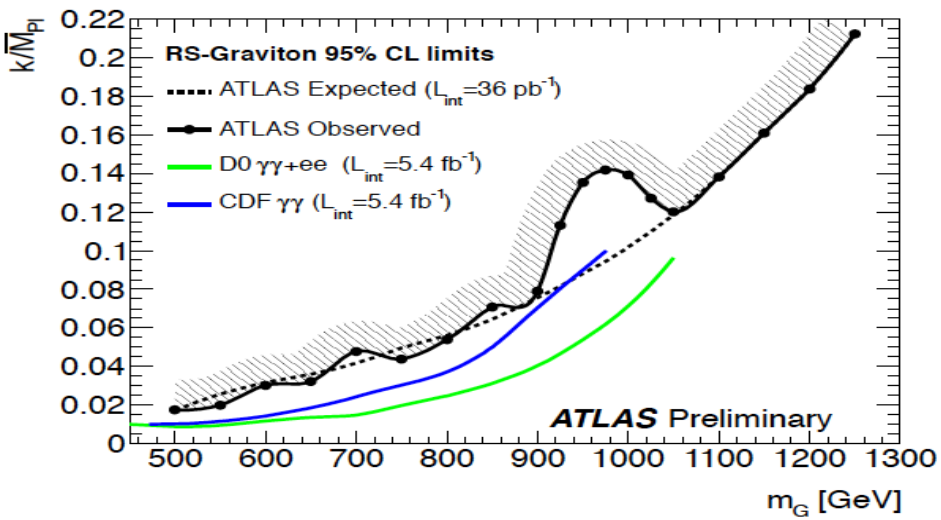
Diphoton Exotics

ATLAS-CONF-2011-044

- **Randall-Sundrum Model for the hierarchy problem**
- **Massive graviton predicted**

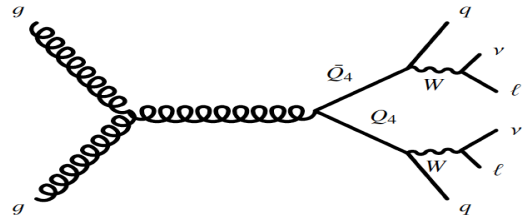




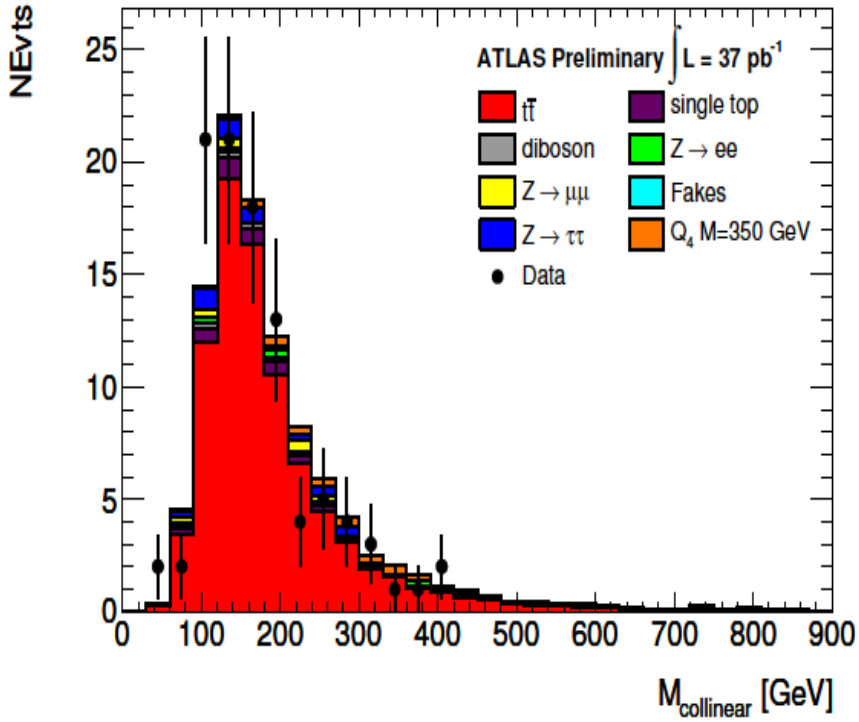


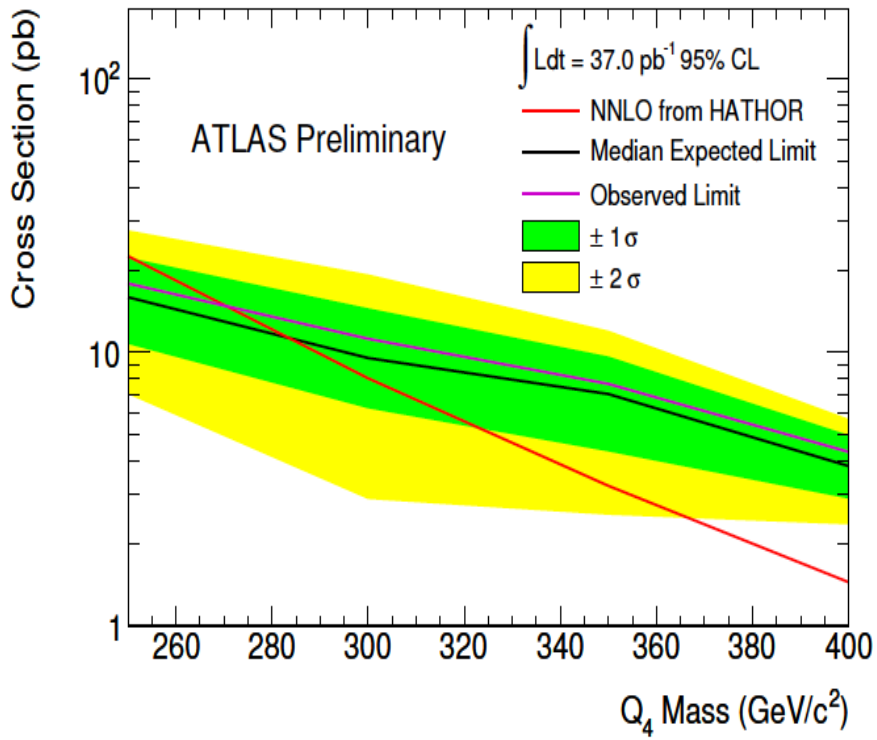
4th Generation Quark

ATLAS-CONF-2011-022



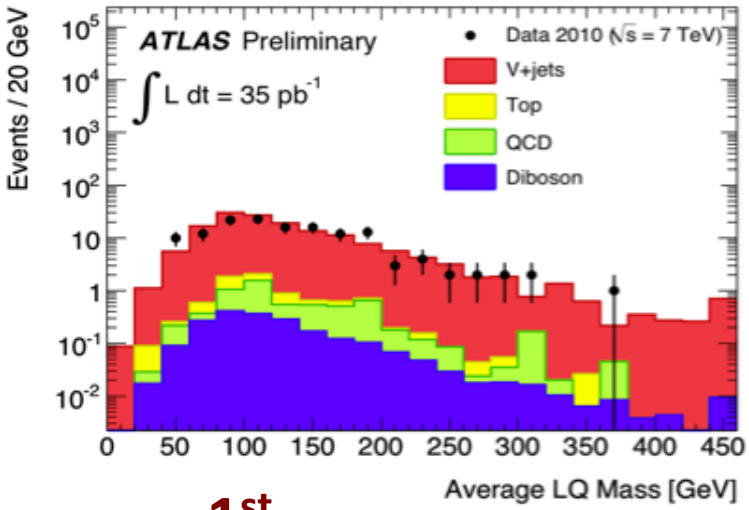
$$Q_4\bar{Q}_4 \rightarrow W^+qW^-\bar{q} \rightarrow \ell^+\nu q\ell^-\nu\bar{q}.$$

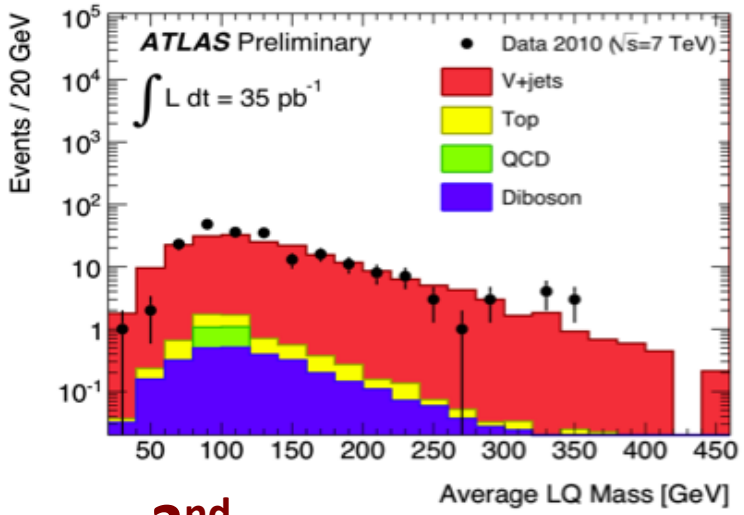




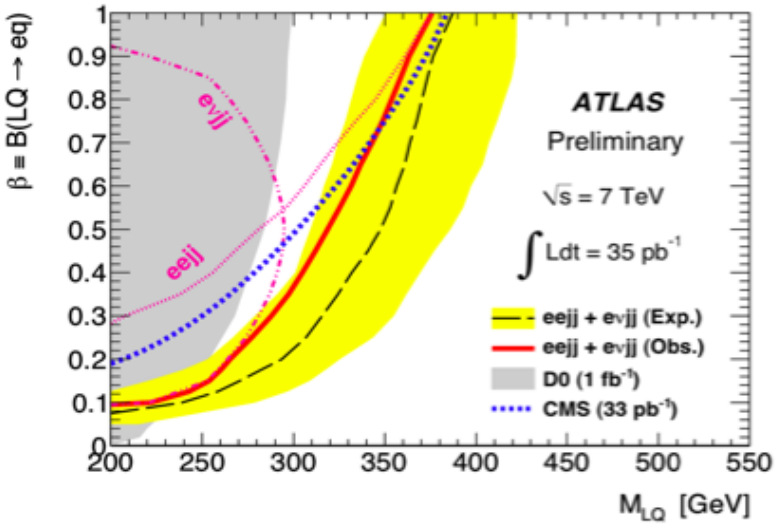
Leptoquark

llqq+lνqq

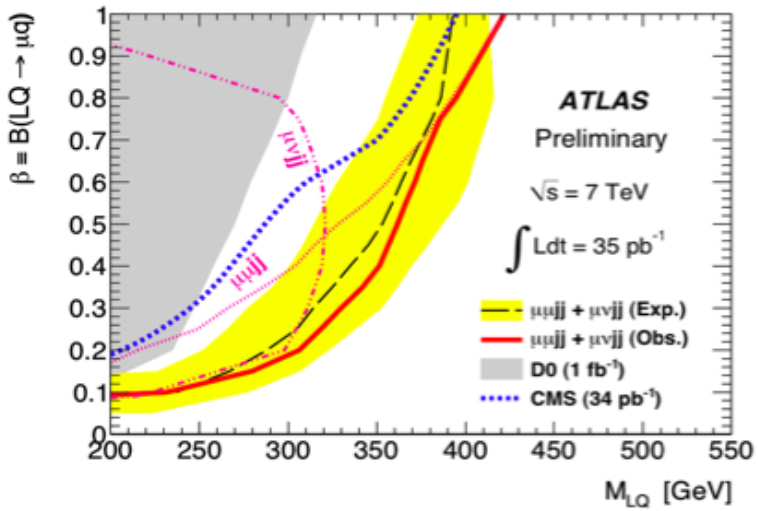




1st



2nd

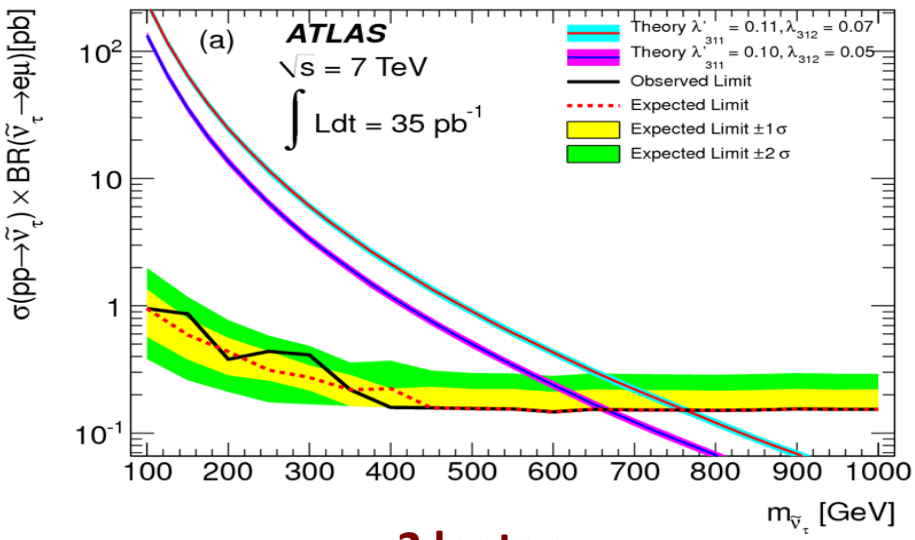


SUSY: Other Results

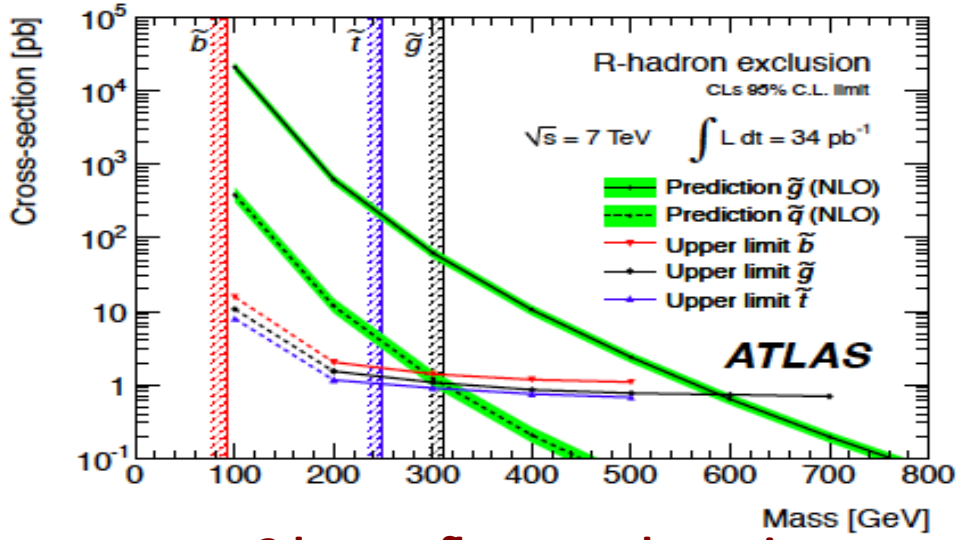
arXiv:1103.5559 arXiv:1103.1984

arXiv:1103.6214 arXiv:1103.6208

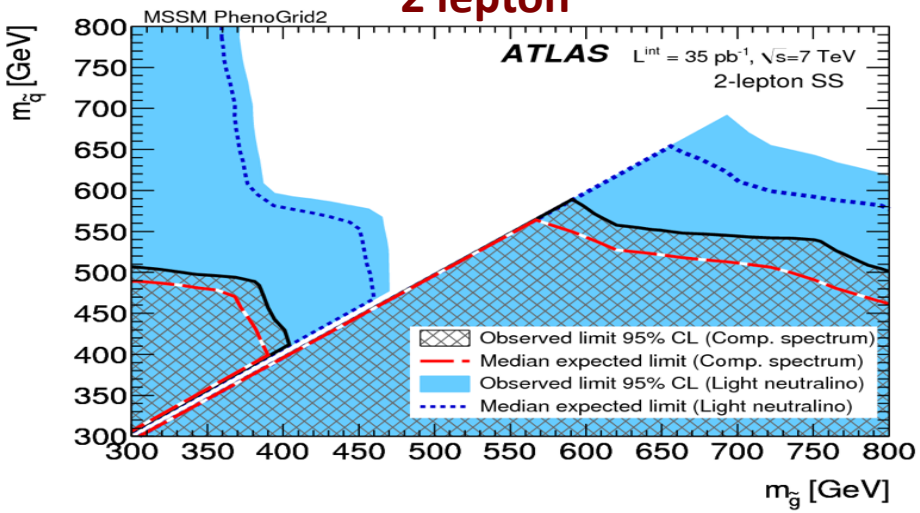
eμ Resonance



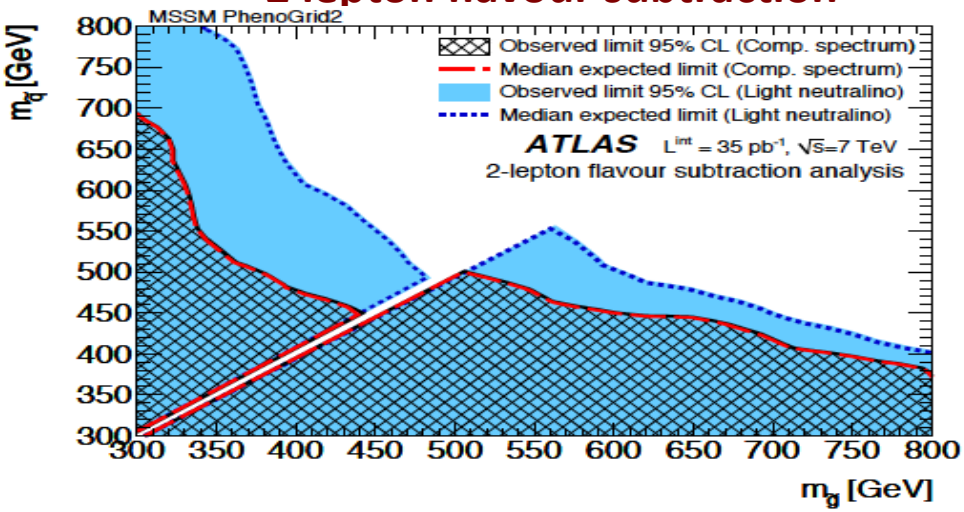
R-Hadron



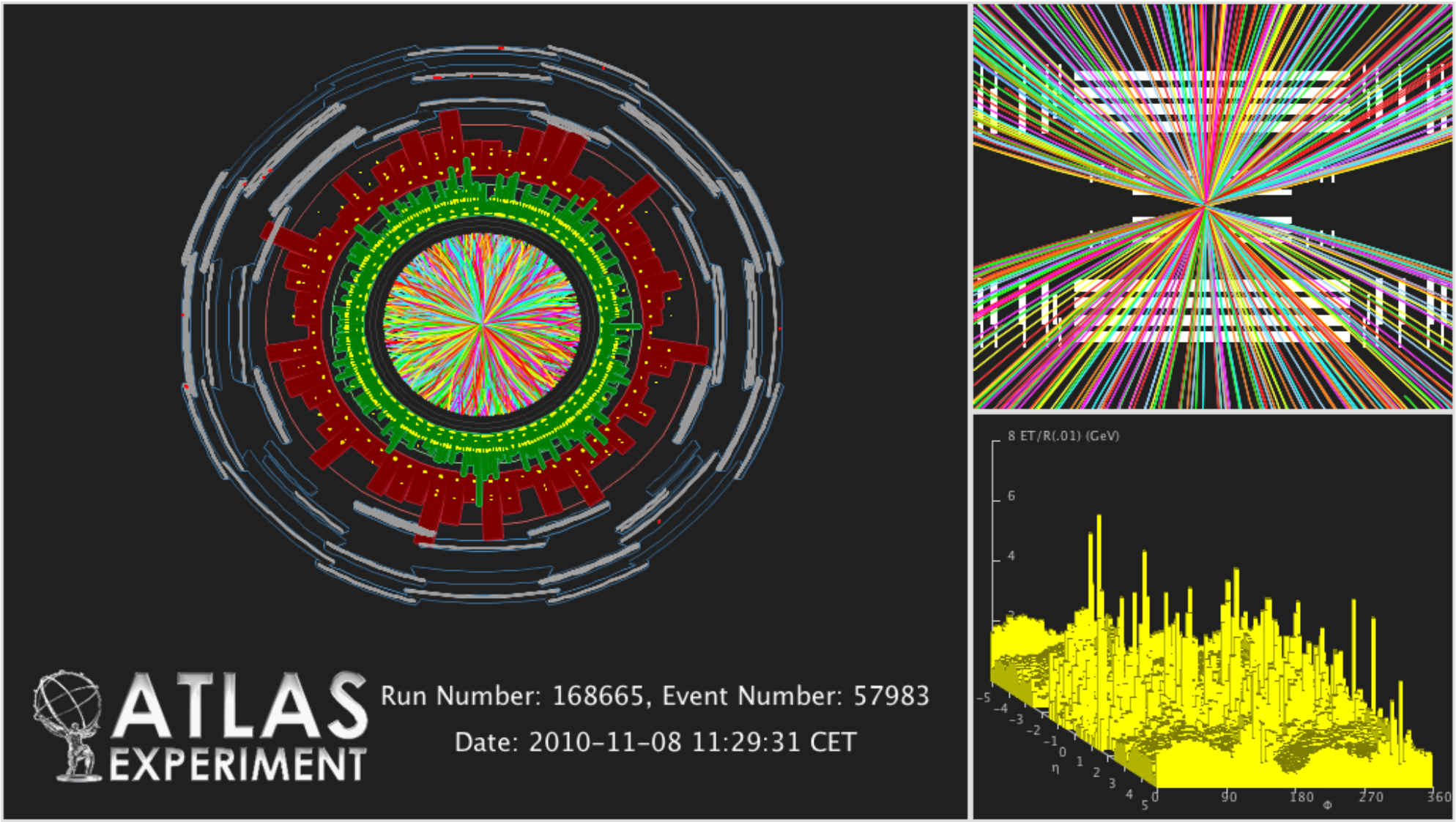
2 lepton



2 lepton flavour subtraction



Pb-Pb Collision

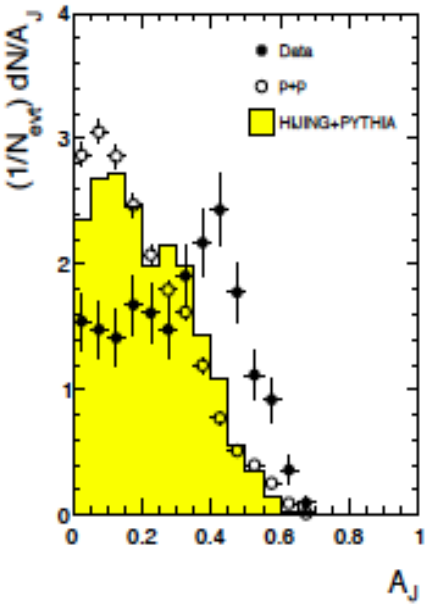


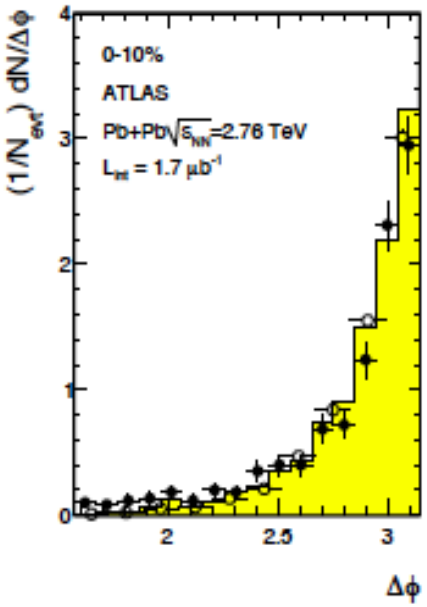
Jet Quenching

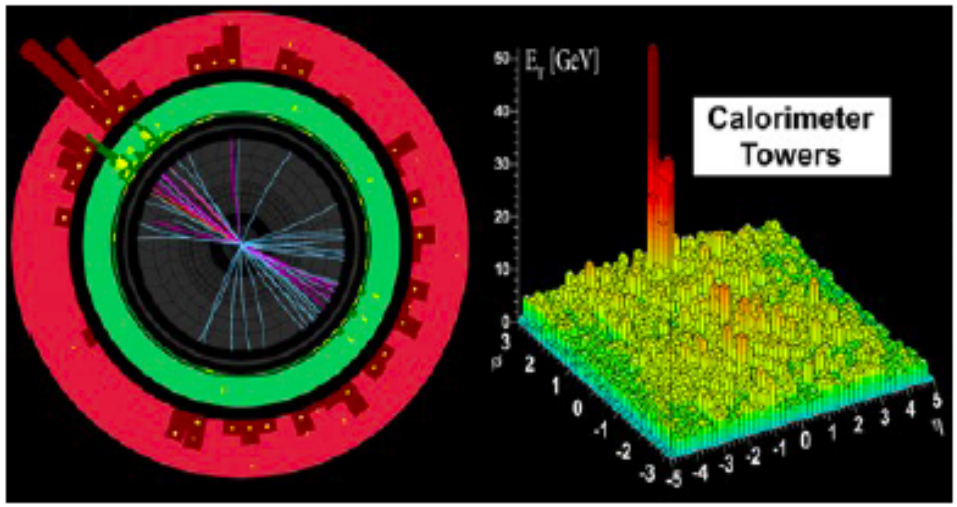
arXiv:1011.6182

- Studying dijet inbalance
- E_{T1} > 100 GeV, E_{T2} > 25 GeV, |η| < 2.8, $\Delta\varphi_{12}>\pi/2$
- Asymmetry increasing with the centrality of the collision (not in p+p collisions)

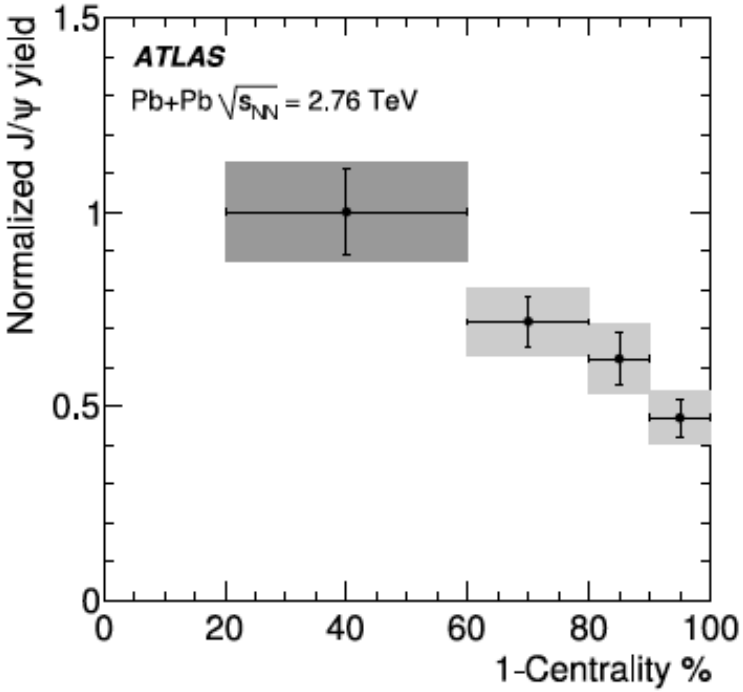
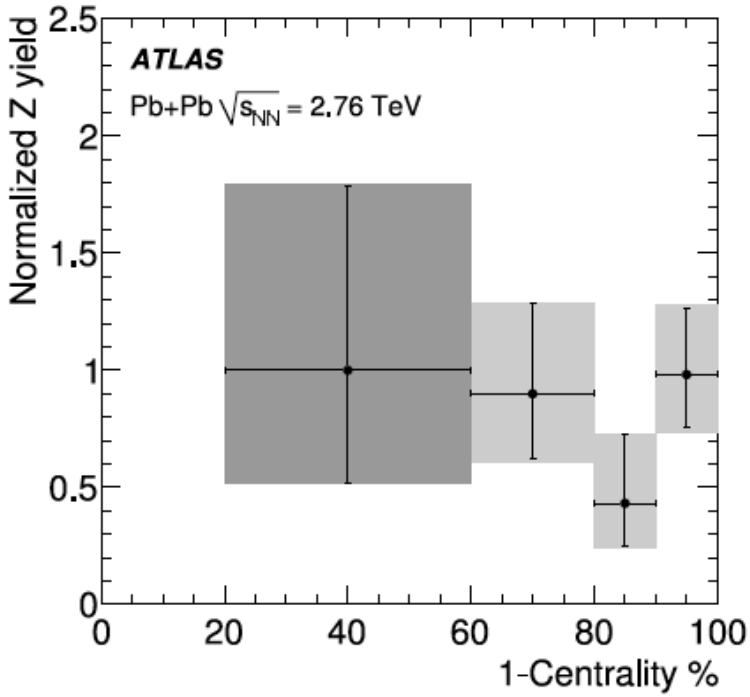
$$A_J = \frac{E_{T1} - E_{T2}}{E_{T1} + E_{T2}}$$







J/ψ Suppression

arXiv:1012.5419

- Centrality dependence of J/ψ suppression invariant with beam energy
- Z suppression not expected but Statistics too low for quantitative statement