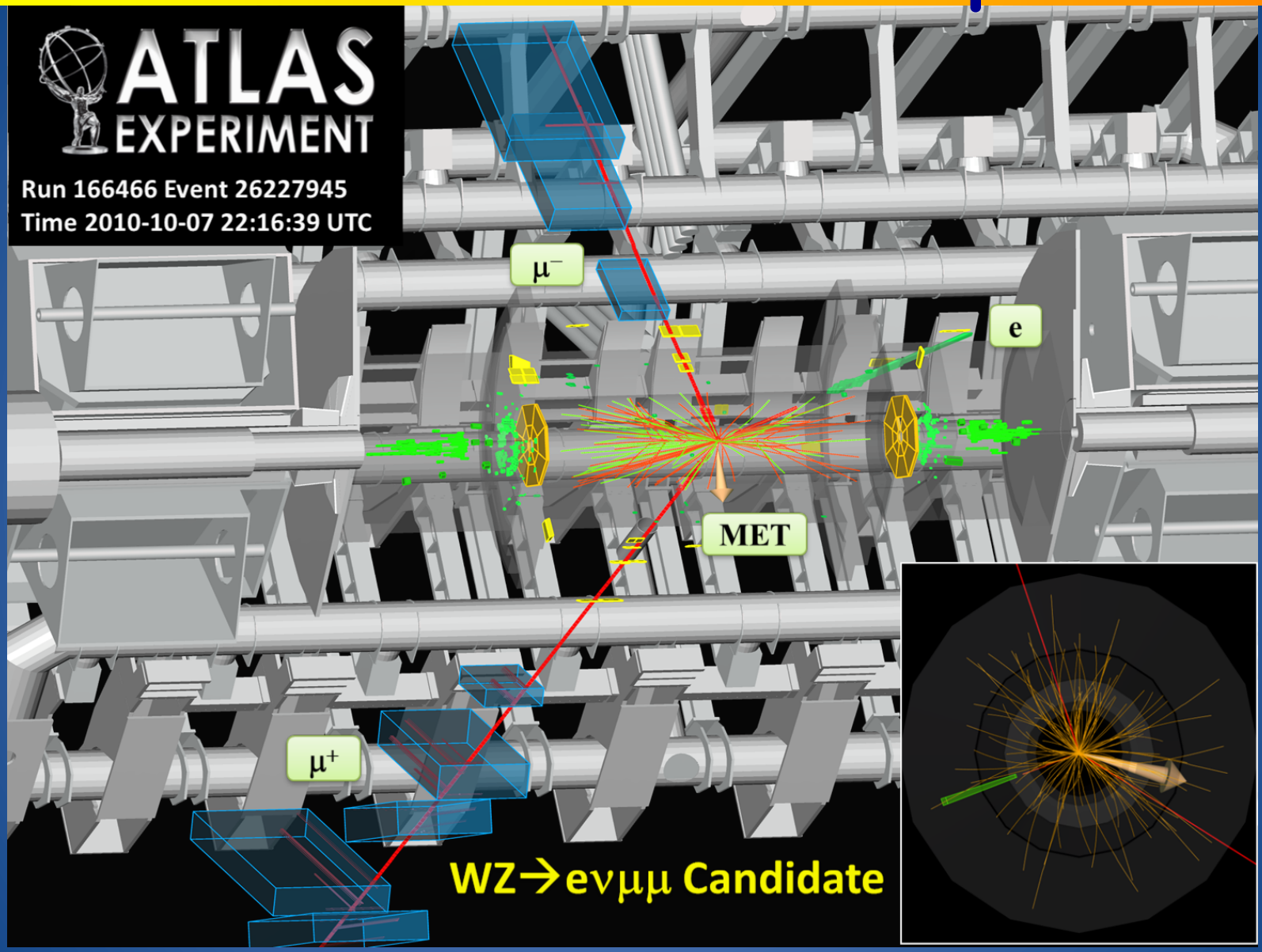
ATLAS: Status Report

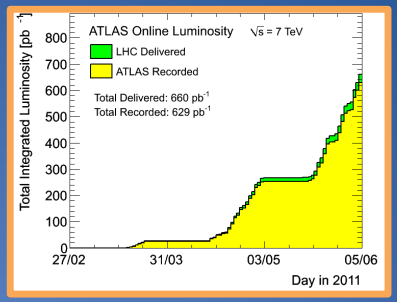


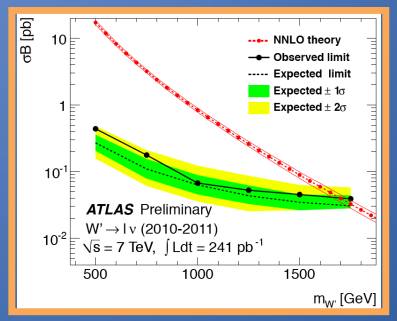
PLHC, Perugia 6/6/2011

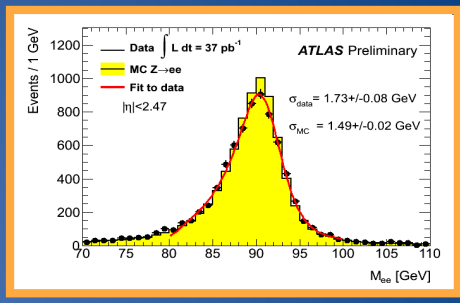
L. Pontecorvo on behalf of the ATLAS Collaboration

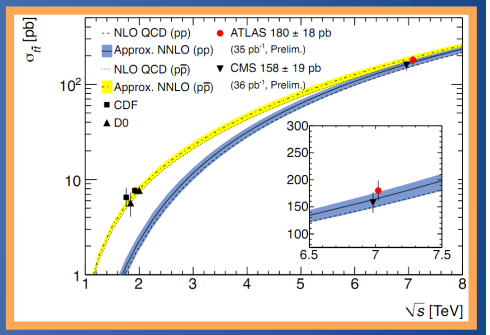
Outline

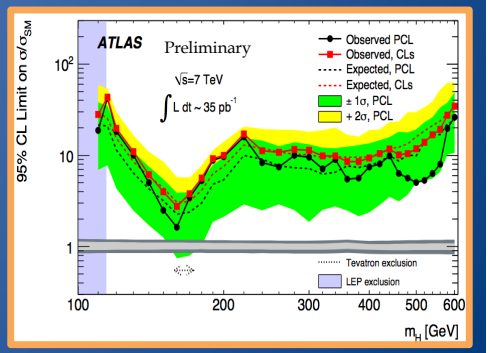
- Detector Operation
- Performance
- Selected HI results
- Highlights on SM Physics
- Exotic and SuSy Searches
- Higgs Searches
- Conclusions



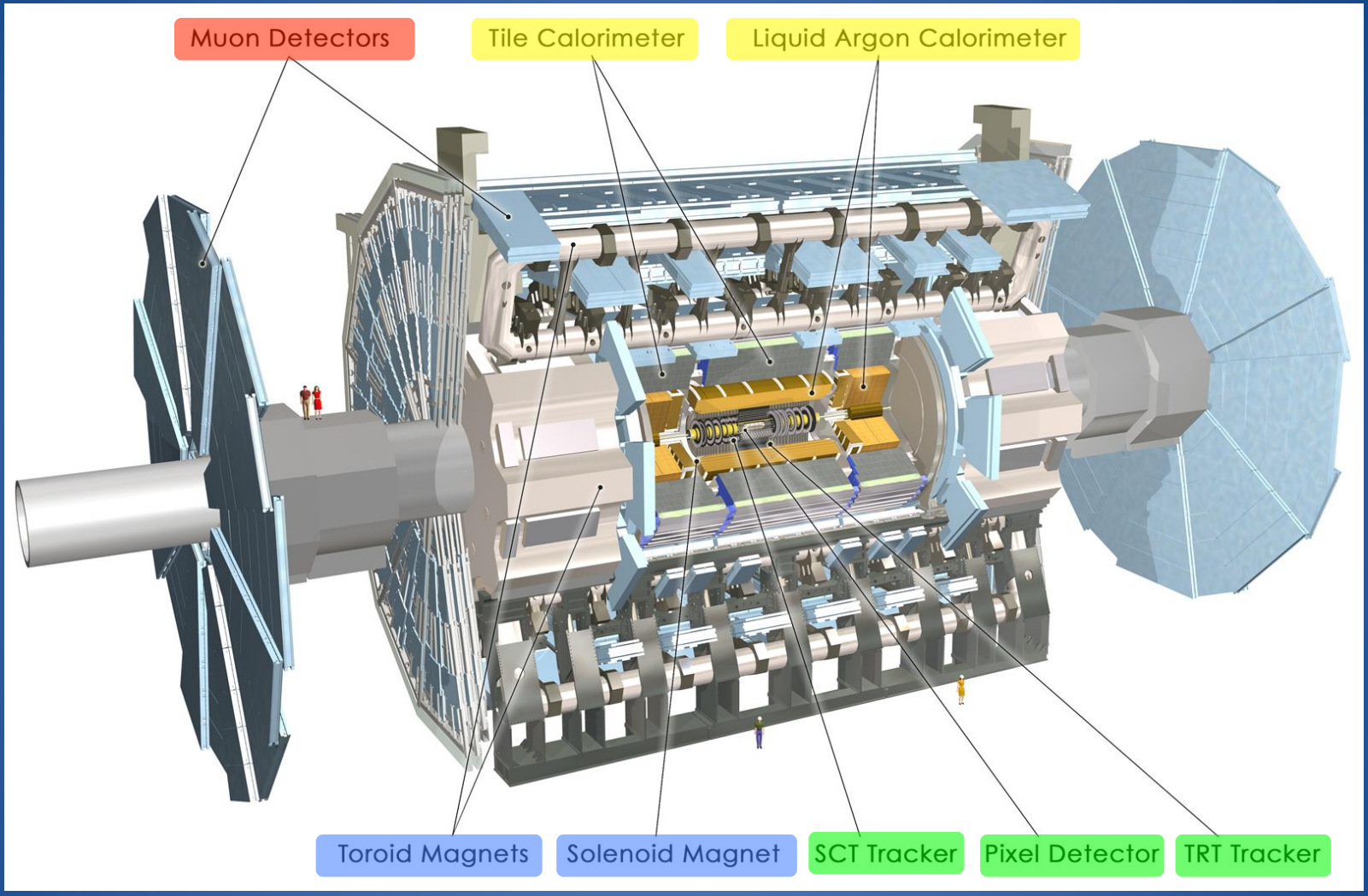








The ATLAS Detector (in 1 Slide)



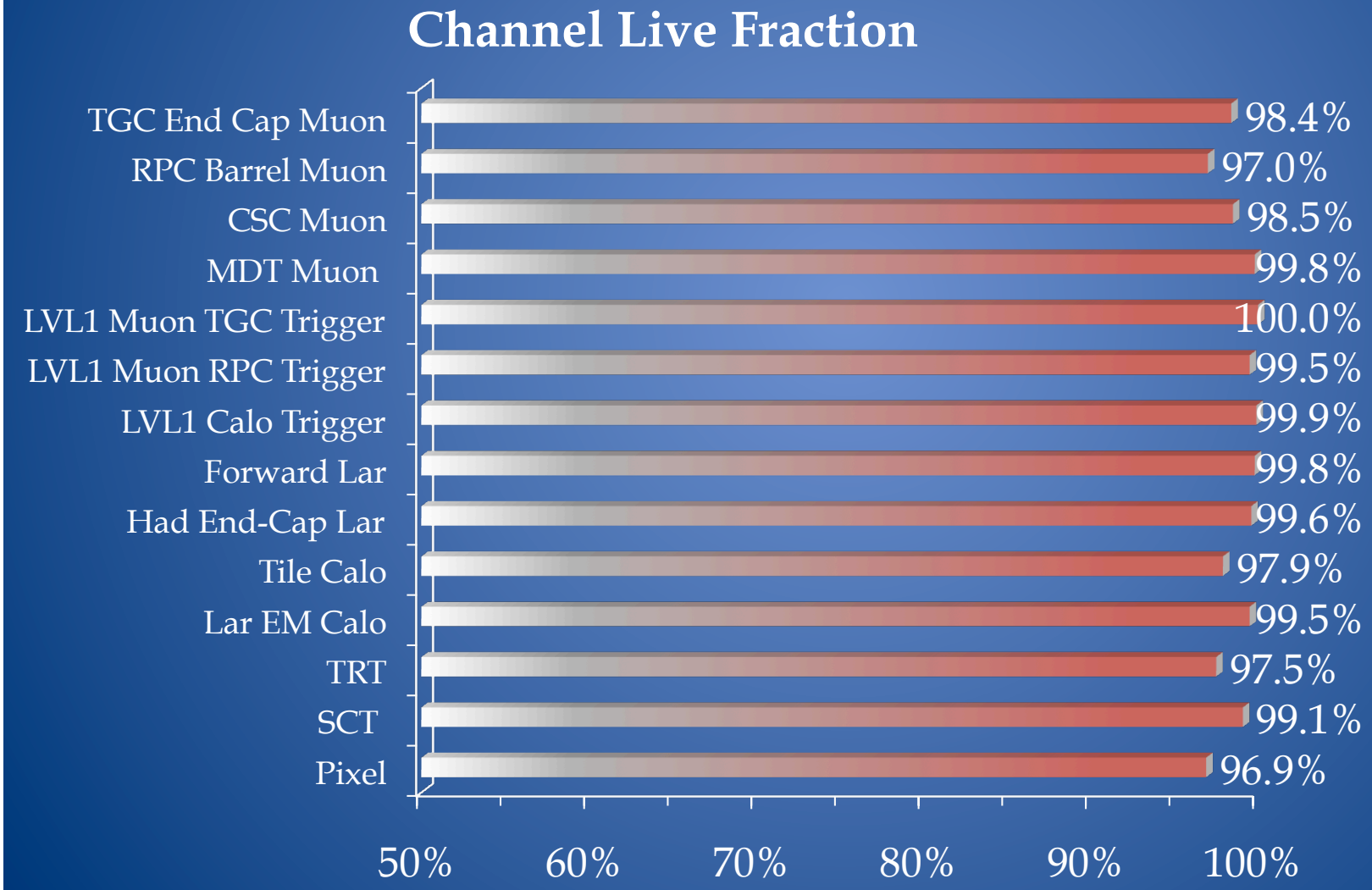
4 Superconducting magnets: Central Solenoid (B= 2T)

3 Air core Toroids

Inner detector Calorimetry Muon Spectrometer

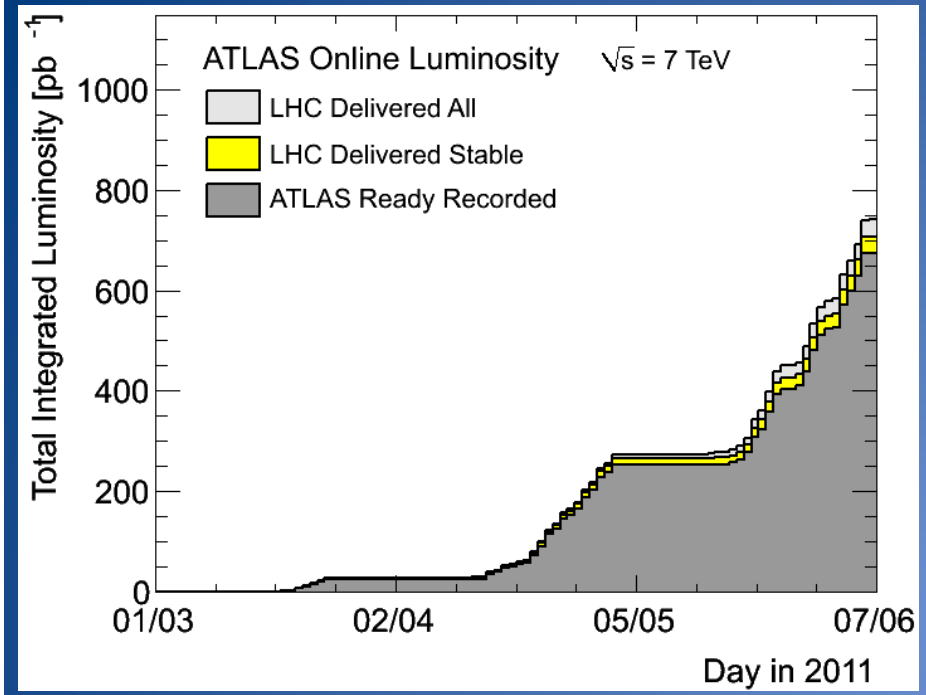
Detector Operations

- Fraction of operational channels close to 100 % for all systems



Number of Channels
320 K
370 K
31 K
350 K
320 K
370 K
7 K
3.5 K
5.6 K
9.8 K
170 K
350 K
6.3 M
80 M

Data taking efficiency



Max inst lumi. : 1.26×10^{33} cm^{-2} s^{-1}

Delivered luminosity: 709 pb^{-1}

ATLAS ready recorded: 676 pb^{-1}

Preliminary uncertainty on 2011 luminosity 4.5%

Data taking efficiency: >95%

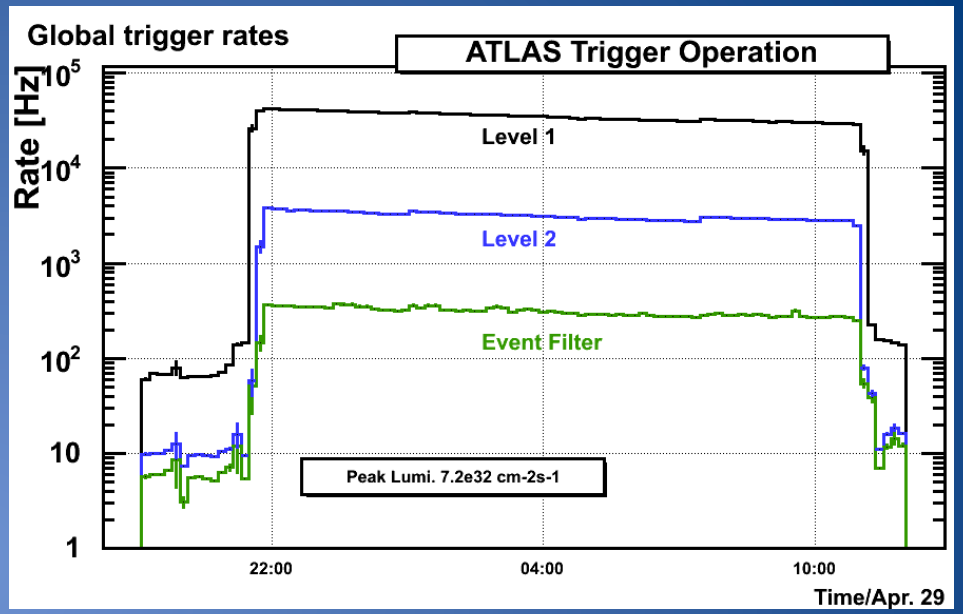
Fraction of good quality data per detector

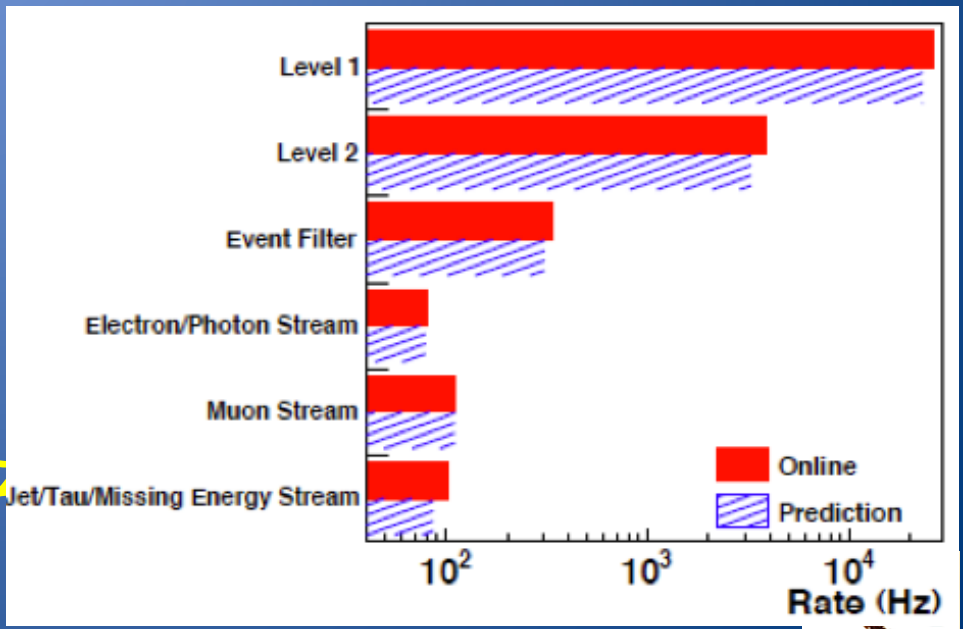
Inner Tracking Detectors			Calorimeters				Muon Detectors				Magnets	
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.5	99.4	100	87.5	92.4	94.5	100	100	99.0	99.9	99.8	96.8	95.1

Fraction of recorded data used for Top analysis : 83%

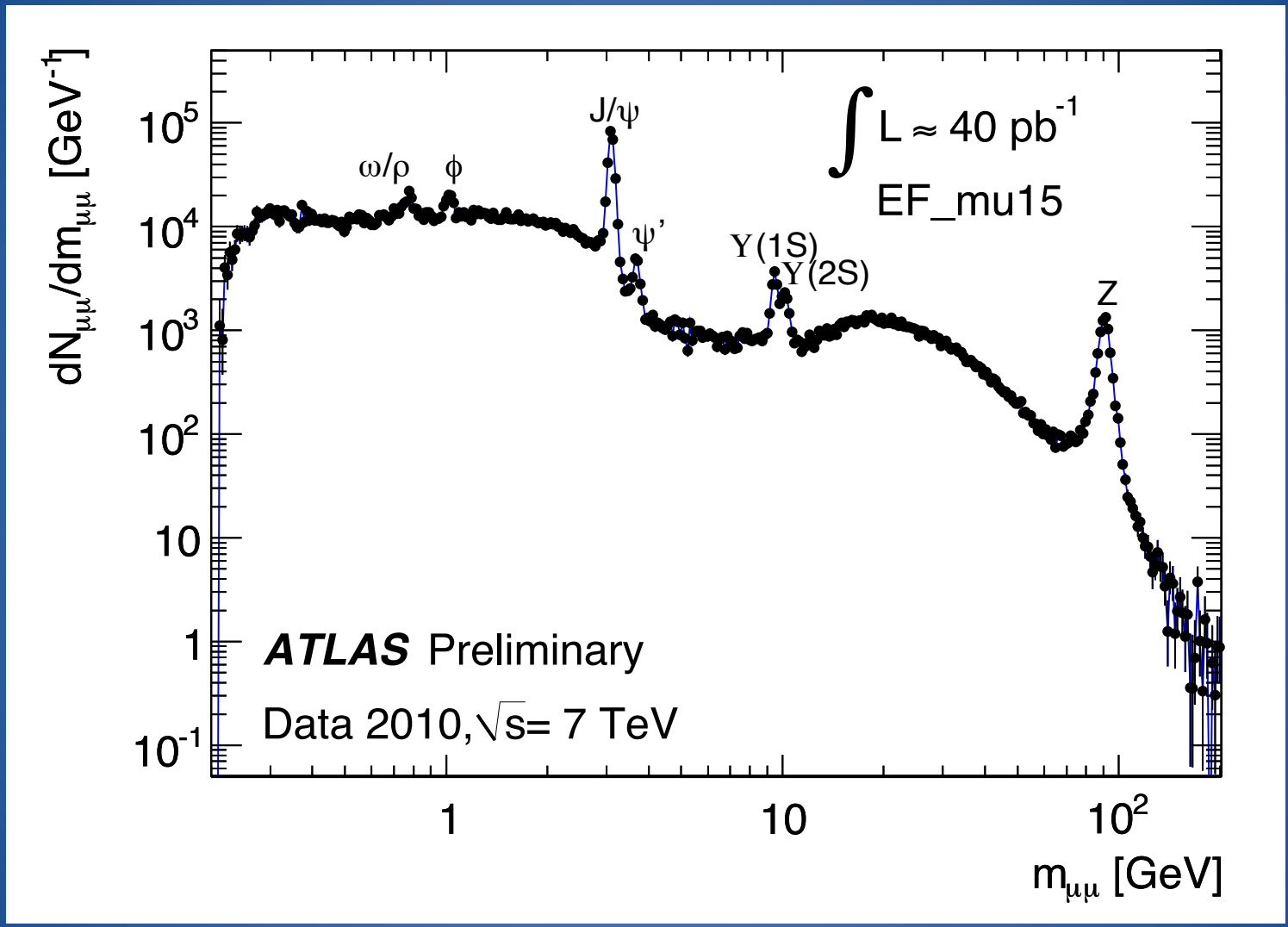
Trigger operations

- Trigger organized in 3 levels
  - LVL1 (50 KHz): Hardware
  - LVL2 (4 KHz): Software on reduced granularity (regions of interest)
  - EF (≈300 Hz): Based on Offline Reconstruction Full Granularity
- Rates of physics objects very well understood and under control.
- Recorded physics rate ≈300 Hz





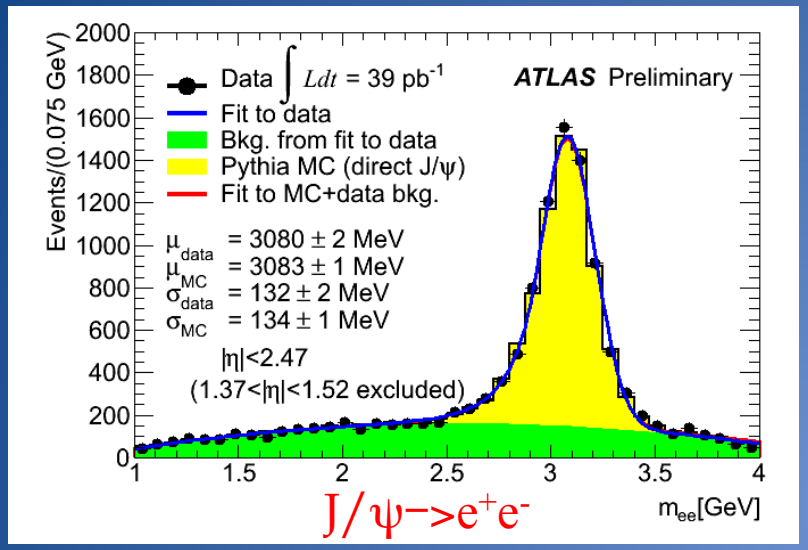
Performance

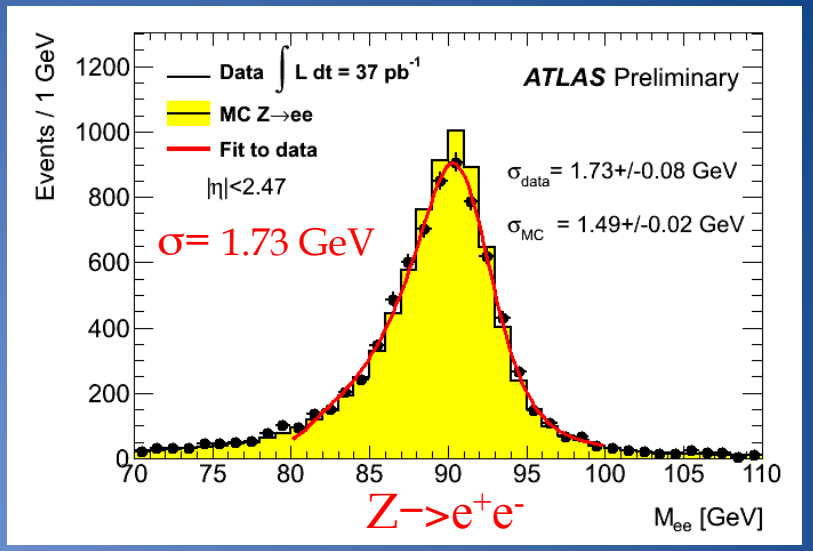


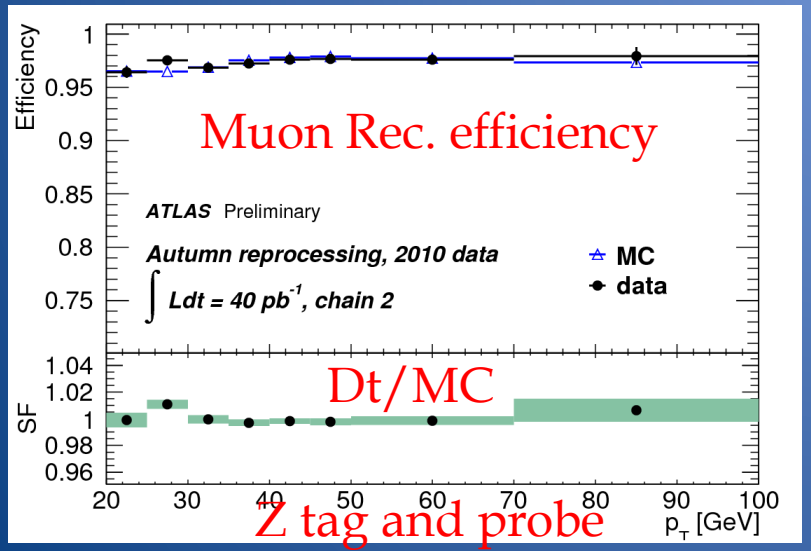
- Calibrating the detector performance with Nobel Prize winning particles

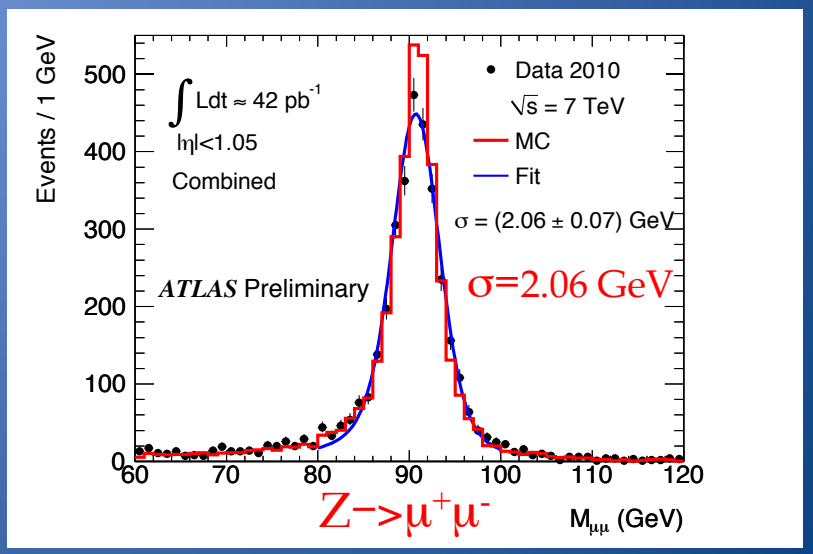
Electrons and Muons

Electrons: Excellent resolution (1.9% @ Z) and linearity down to very low Pt







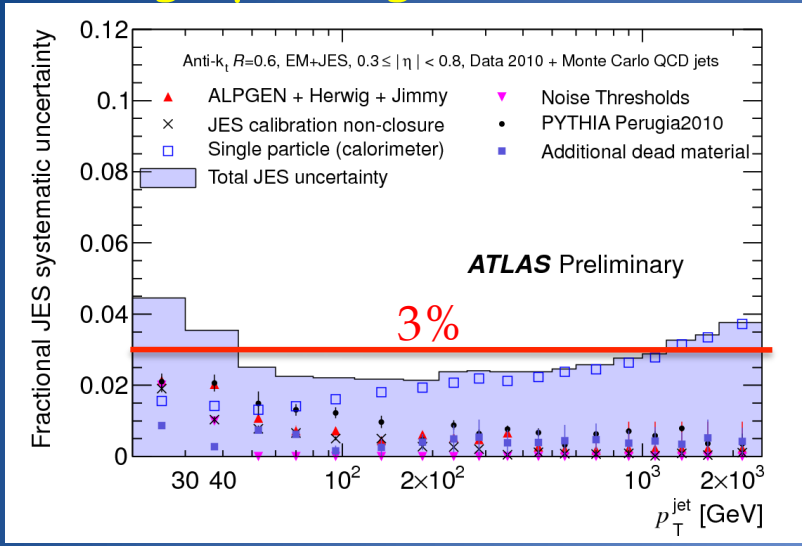


Muons: high and well understood reconstruction efficiency,

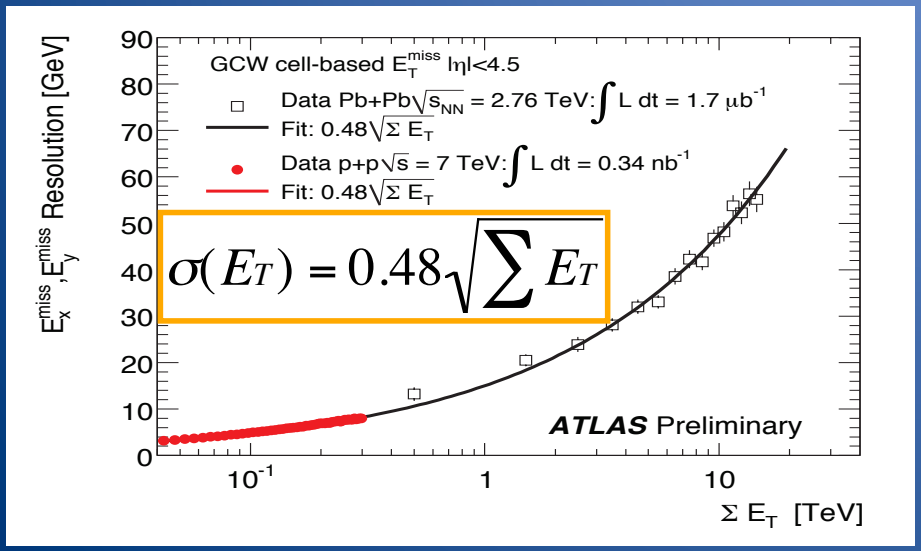
Excellent resolution: (@Z: 2 % in Barrel, 3% in EndCap) and scale <1%

Jets, E_T^{Miss} and B tagging

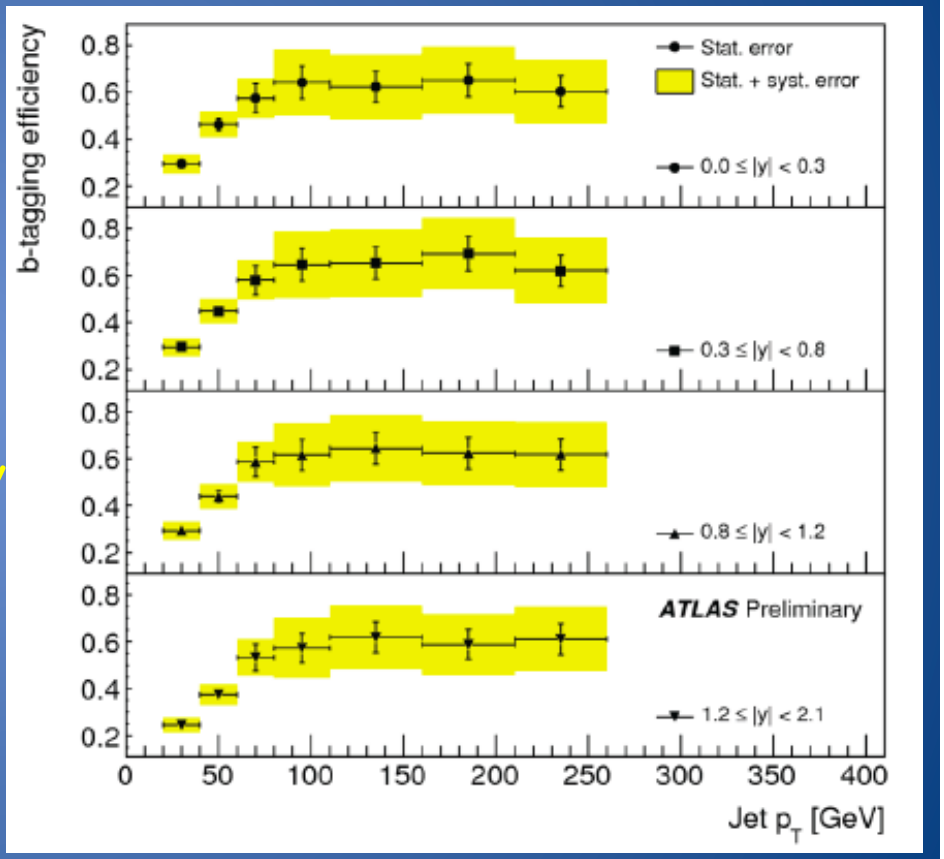
Jet Energy Scale: systematic uncertainty <3% in a large pt range (2010 data no pile-up)



Missing Et Resolution : tested up to very high Σ E_T using Heavy Ions data



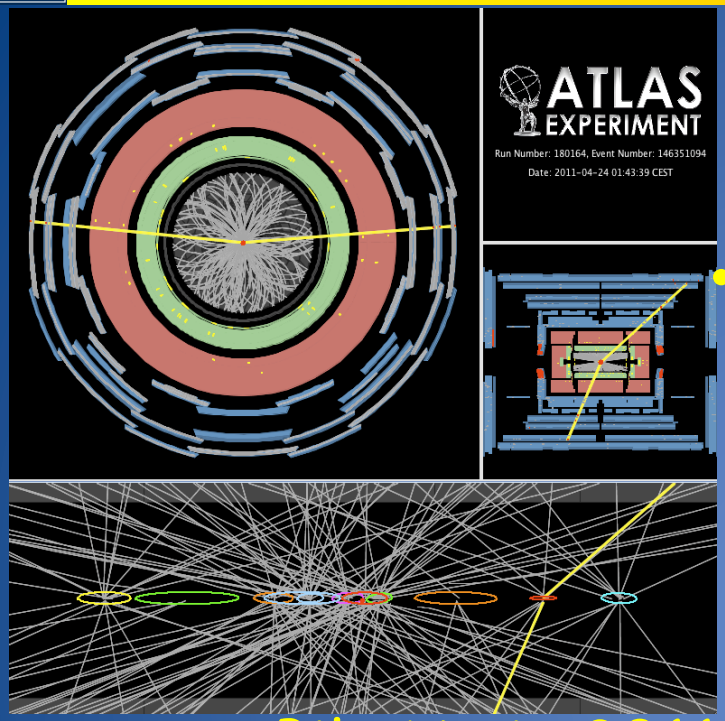
B tagging (SV0)



Efficiency 40-60%

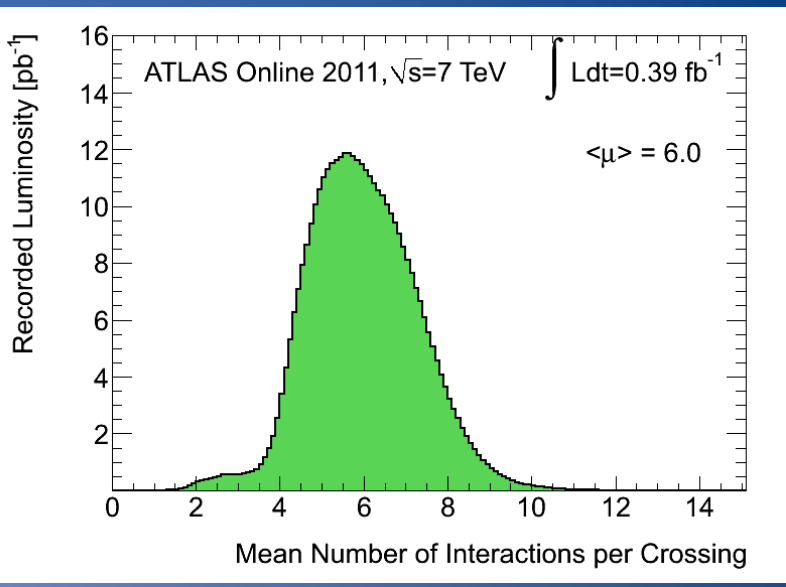
Mis-tag rate : 0.2-1%

Pile Up



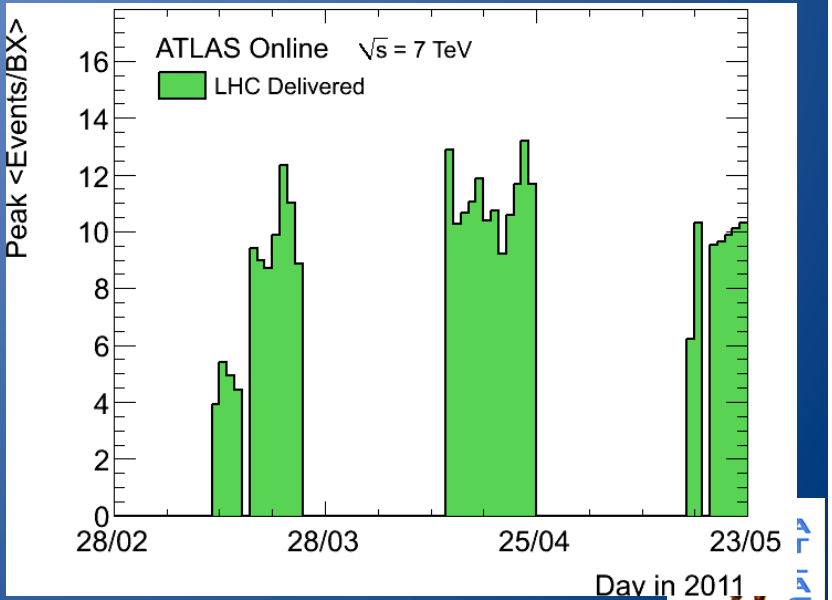
- Event with 11 vertices and 1 Z

Average # of interactions per crossing



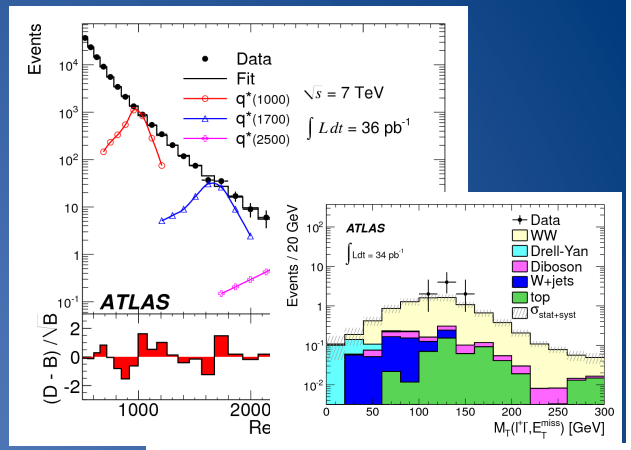
- Average Pile Up in 2011 : 6.0 Coll/BC
- Max Pile Up : 10-12 Collisions/BC
- Issue for:
  - Missing energy
  - Lepton Isolation (mainly calorimetric)
  - Jet Energy Scale and resolution
  - Vertexing
  - CPU time and event size

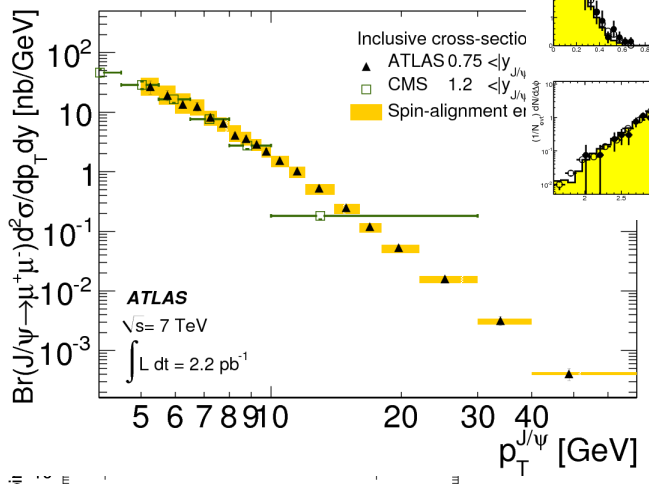
Max Pile up vs time

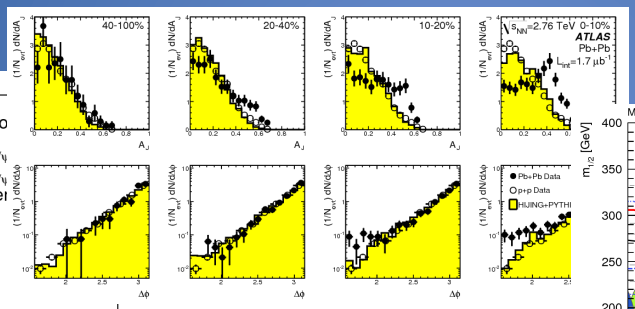


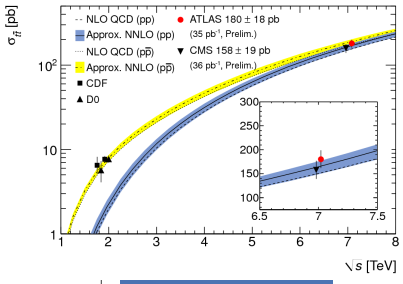
Physics

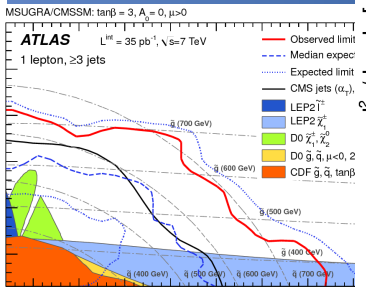
- 36 Physics paper published or submitted
- 88 conf notes published in 2011
  - 8 with 2011 data for this Conference

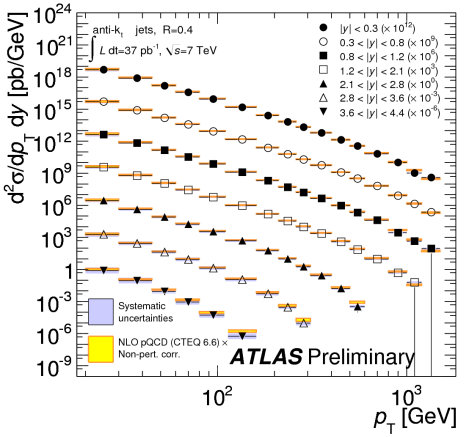


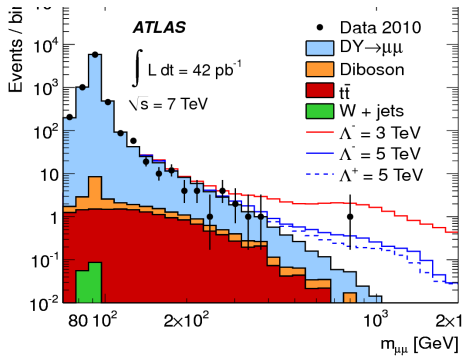


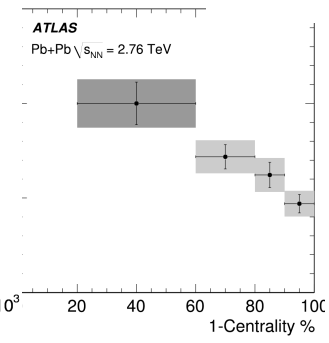


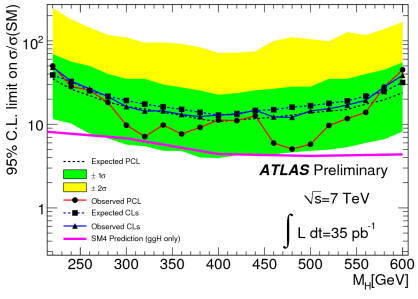


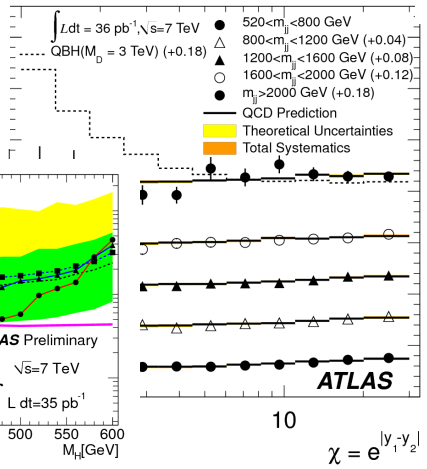


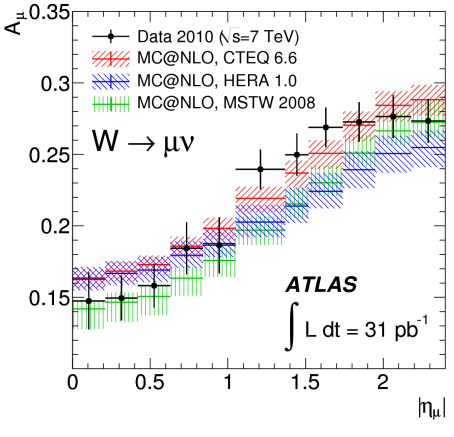






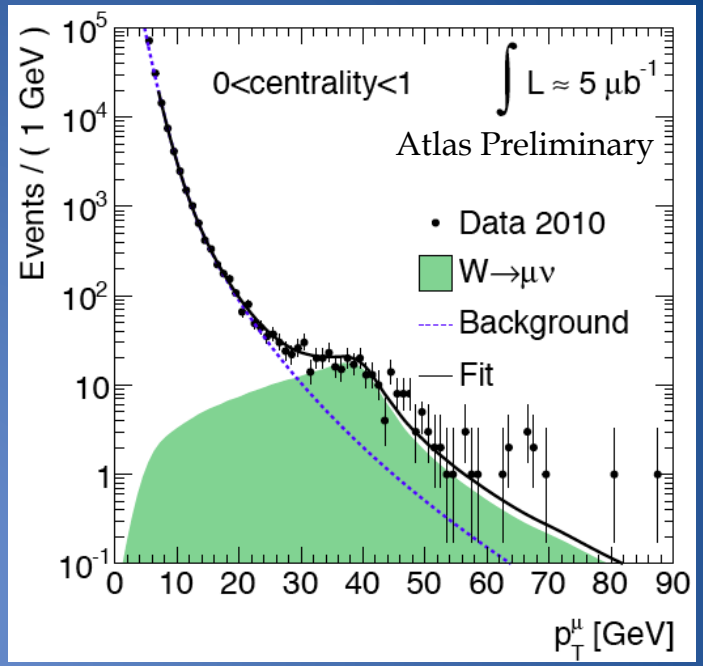


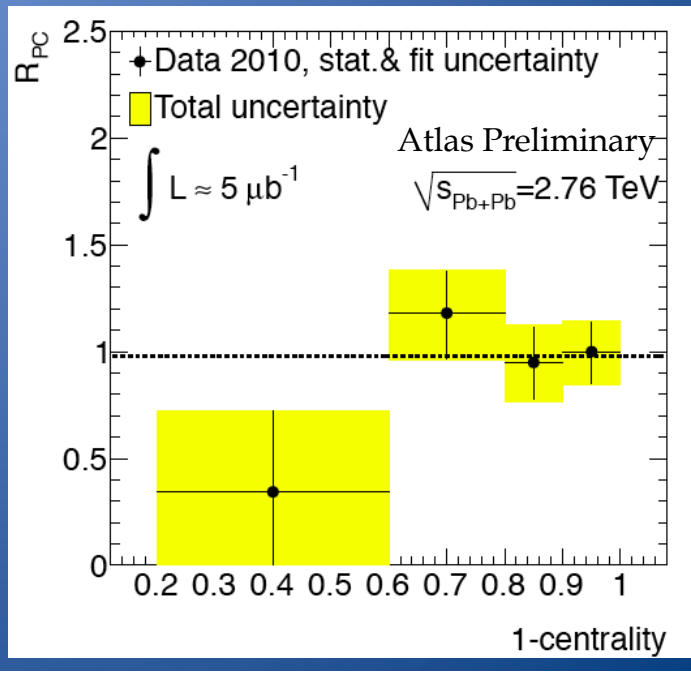




Selected Heavy Ions results

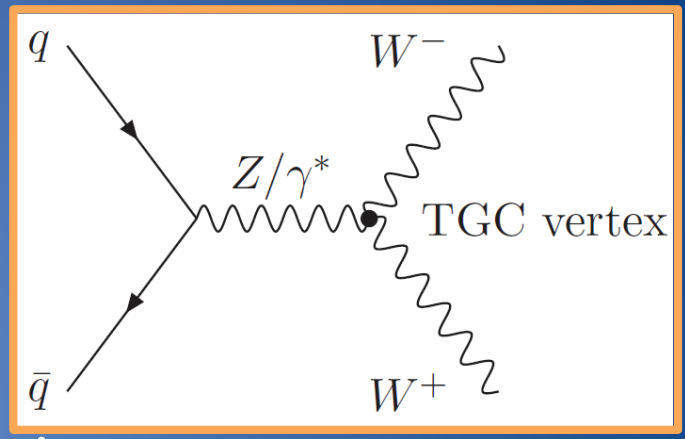
- First direct observation of Jet Quenching
- First publication on J/Psi suppression and Z production in HI at LHC.
  - Both papers sent to journals before Xmas 2010.
- New:
  - Measurement of relative yield (wrt most central bin) of W production in HI vs centrality
  - + many other new measurements (jet quenching, particle flow etc.)





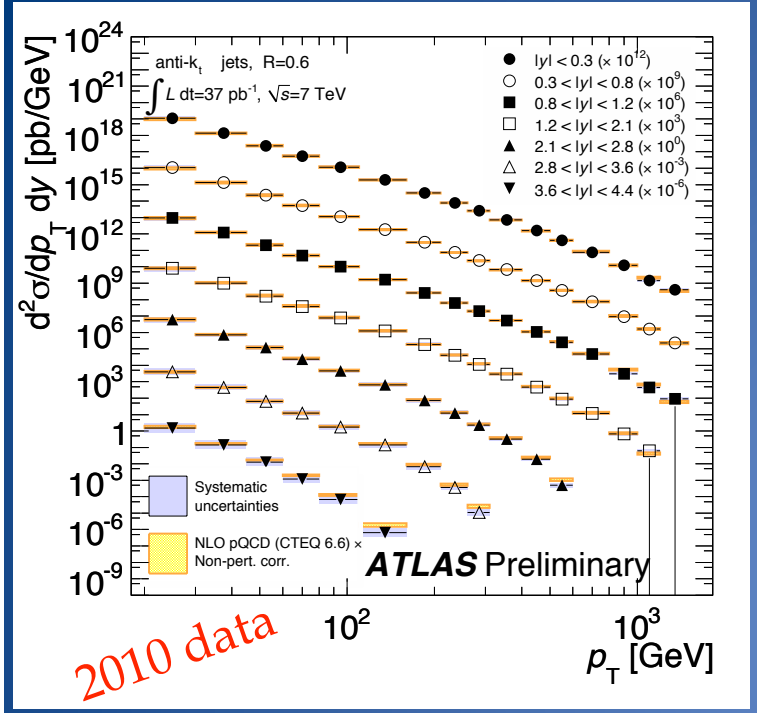
Standard Model highlights

- Measuring the SM processes at 7 TeV extends our knowledge of fundamental physics
  - QCD JET cross section
  - W, Z cross section
  - Di-bosons cross section
  - Top and single Top cross section

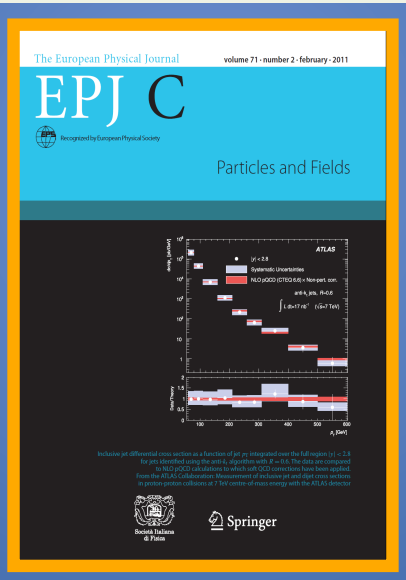


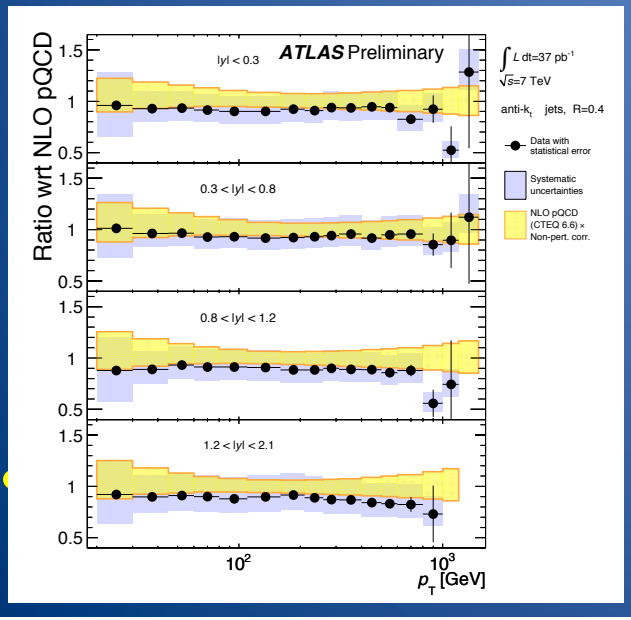
- The above processes are backgrounds for New Physics and Higgs searches
  - Understanding these processes is essential for the quest of New Physics
- Benchmark processes for the understanding of the detector

QCD: Jet results

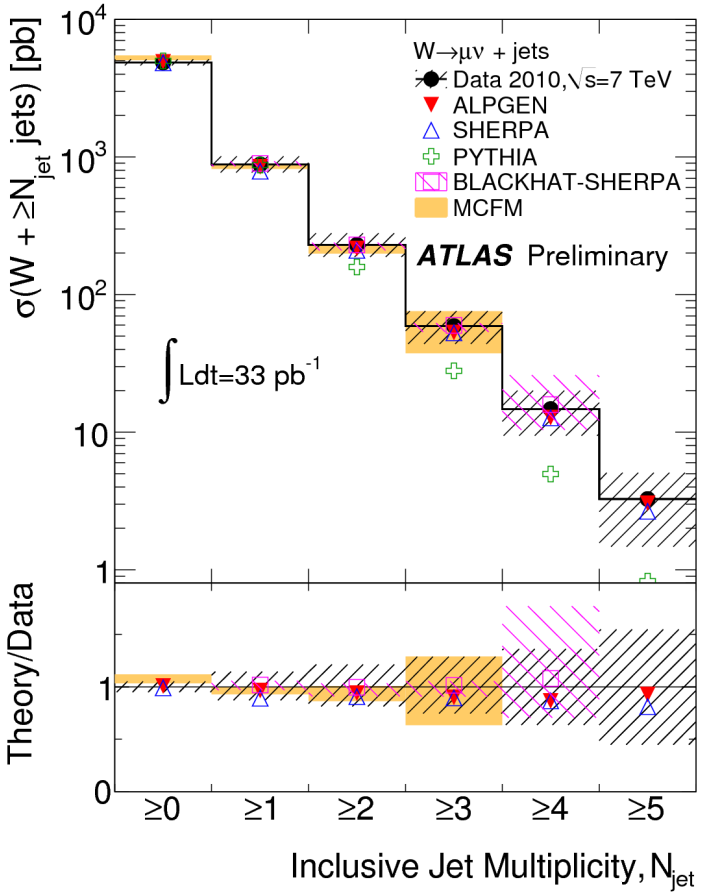


- Double Differential Jet cross section vs Pt
- 7 rapidity bins, up to |y|=4.4 units
- Pt range from 20 GeV to 1.5 TeV
- ~9 orders of magnitude in cross section
- Total uncertainty, from 50% to 10%, dominated by JES

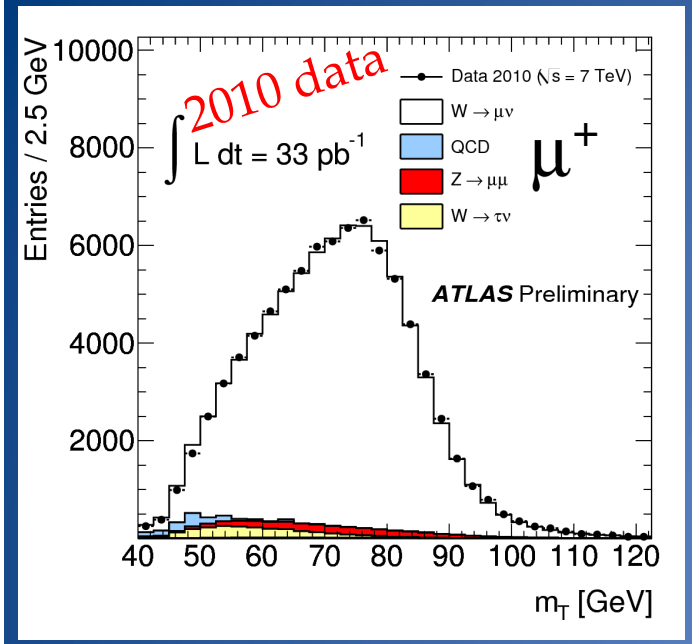


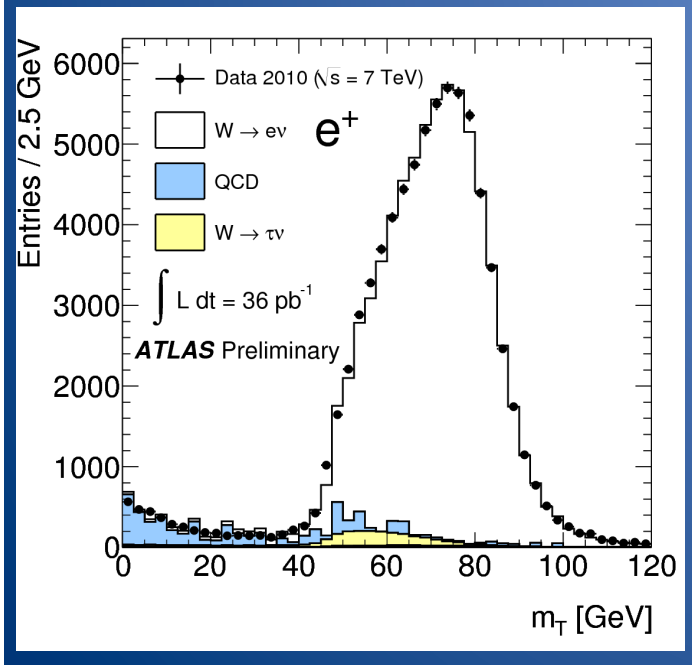


- Jet Multiplicity in W +Jets events very well predicted by AlpGen and Sherpa



W/Z measurements

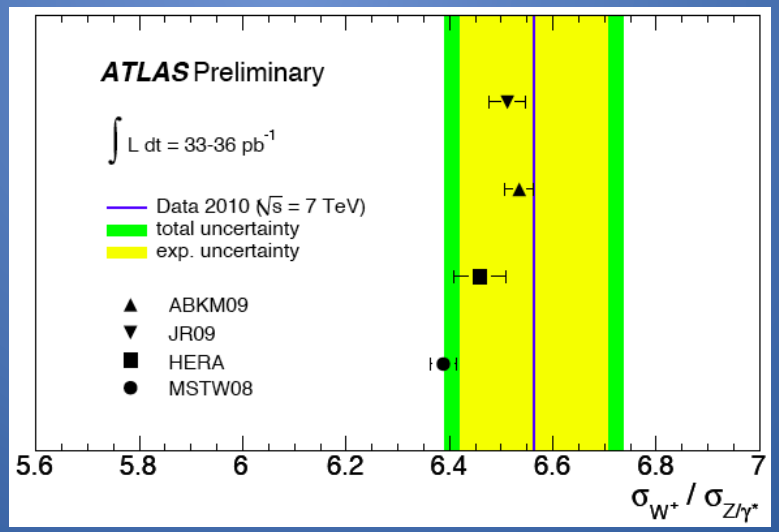




Kinematical distributions are well understood: good agreement Data/MC

Inclusive W-Z cross section and W+/Z cross section ratio

	$\sigma^{tot}_{W^{(\pm)}} \cdot BR(W \to \ell\nu)$ [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^*	$0.945 \pm 0.006(sta) \pm 0.011(sys) \pm 0.032(lum) \pm 0.038(acc)$



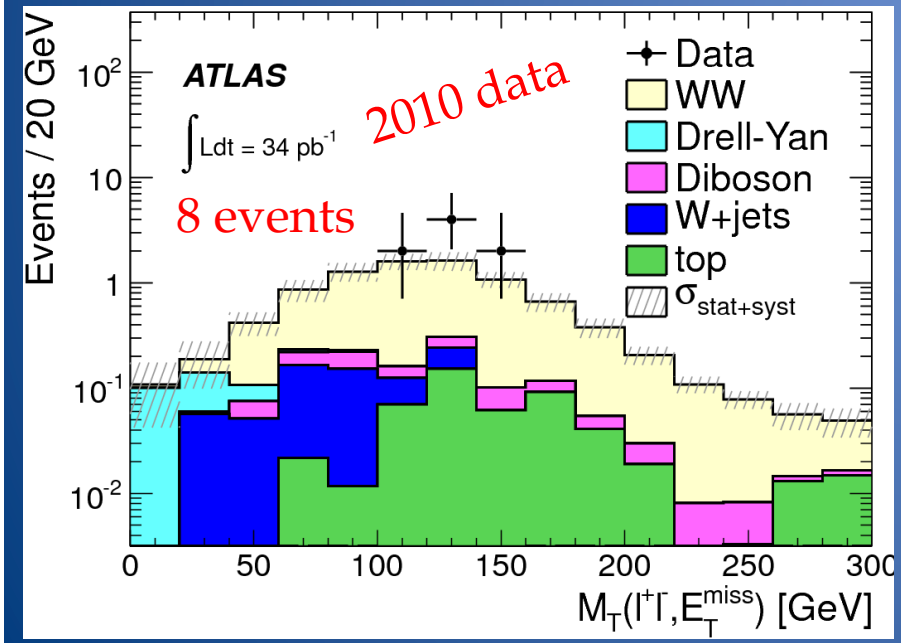
- NNLO predictions consistent with data
- Remarkable success of pQCD and PDFs

- QCD background always estimated with data driven techniques

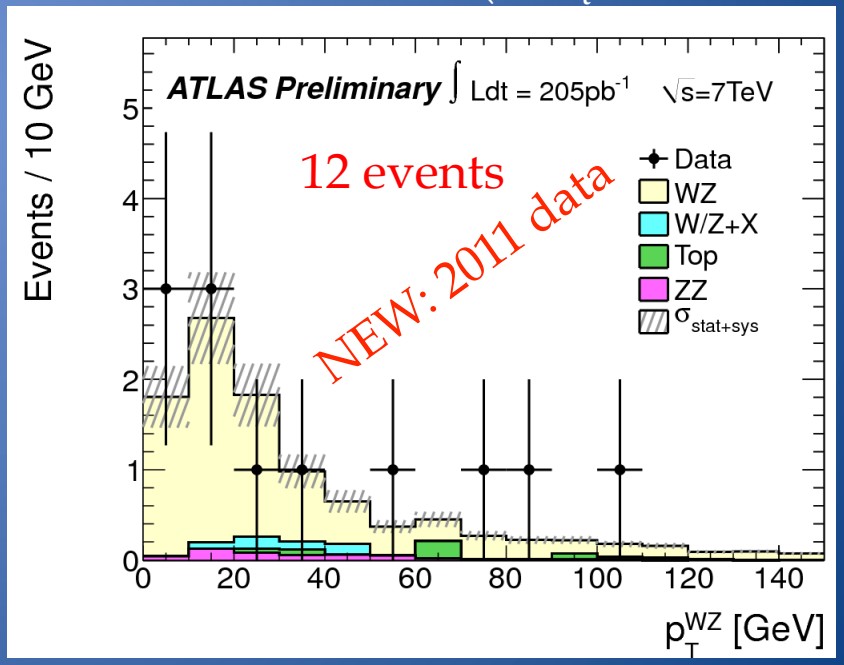
Di-bosons cross section

- Measurement of WW, WZ and Wγ, Zγ production cross section with 2010-11 data
- The goal is to test the non-Abelian nature of the Electro-Weak interaction: Triple Gauge Coupling
- Important background for Higgs and New Physics searches

Trans. Mass (l^+l^-, E_{tmiss}) for WW cand.



Pt distribution of WZ (lll,E_t^{miss}) Candidates

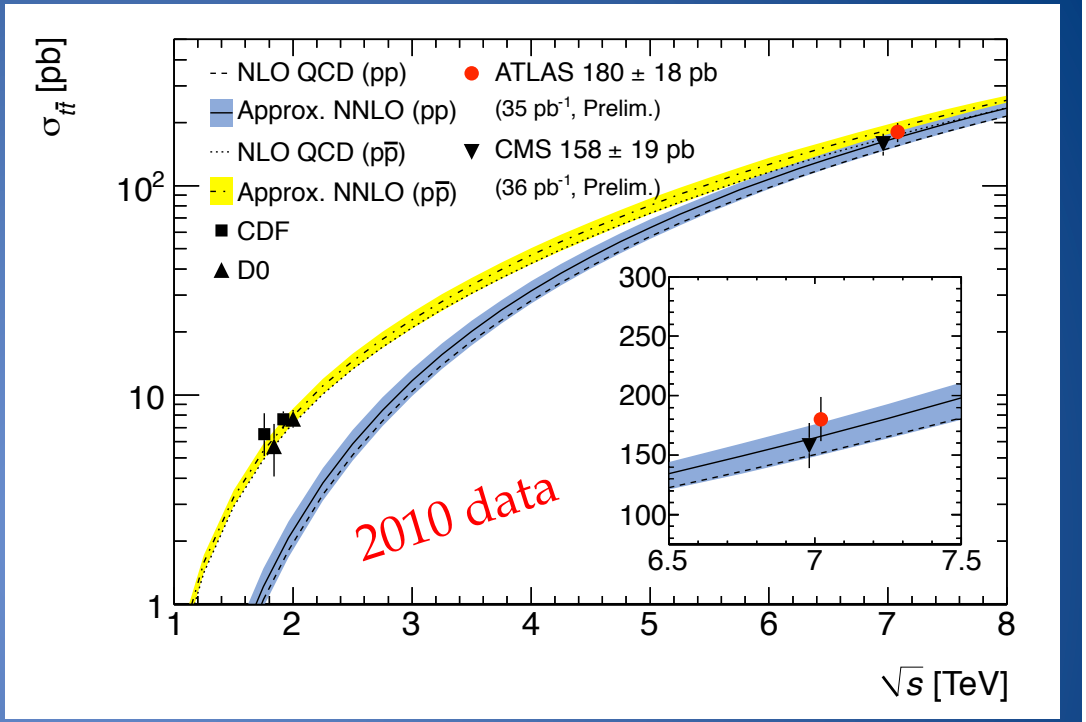


$$\sigma_{WW} = 40^{+20}_{-16}(stat) \pm 7(syst)\,pb$$

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

Top Cross Section

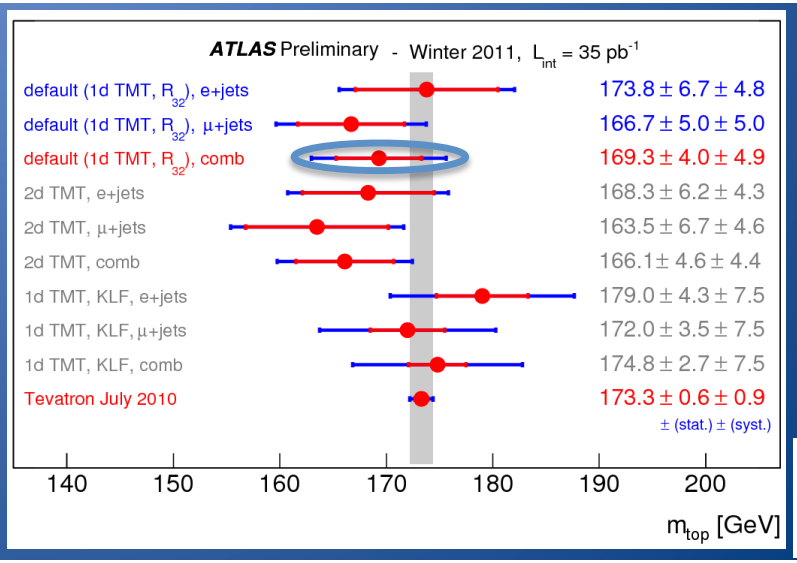
- Top production cross section obtained combining 5 different analyses:
  - e+jets, with b-taging
  - μ+ jets, with b-tagging
  - ee+jets (w/o b-tagging)
  - μμ+jets (w/o b-tagging)
  - eμ+jets (w/o b-tagging)



σ(tt) = 180 ± 9± 15 ± 6 pb
[10% total uncertainty]

- Top Quark Mass measured in the Lepton + Jets channel.

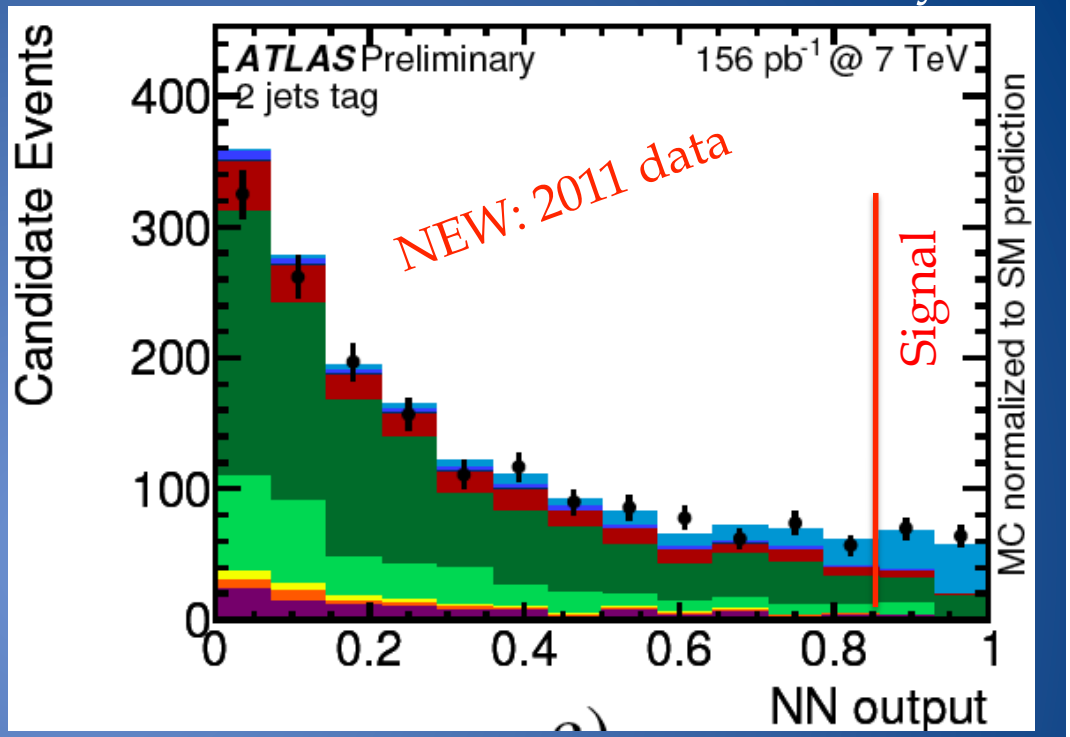
M_t = 196 ± 4.0± 4.9 GeV



Single Top Cross section

- Single Top production is a direct probe of the W-t-b coupling and is sensitive to New Physics
- Events selection: exactly 1 lepton, 2 jets (1 B-tagged) and E_t^{miss}>25 GeV
- Main backgrounds: MultiJet, W+ Jets, tt
- Two analyses:
  - Cut and Count (C-C)
  - Neural Network

Nb of candidate events in NN analysis



SM cross section for t-channel

$$\sigma_{t\,SM} = 66.2\,pb$$

Neural Network result

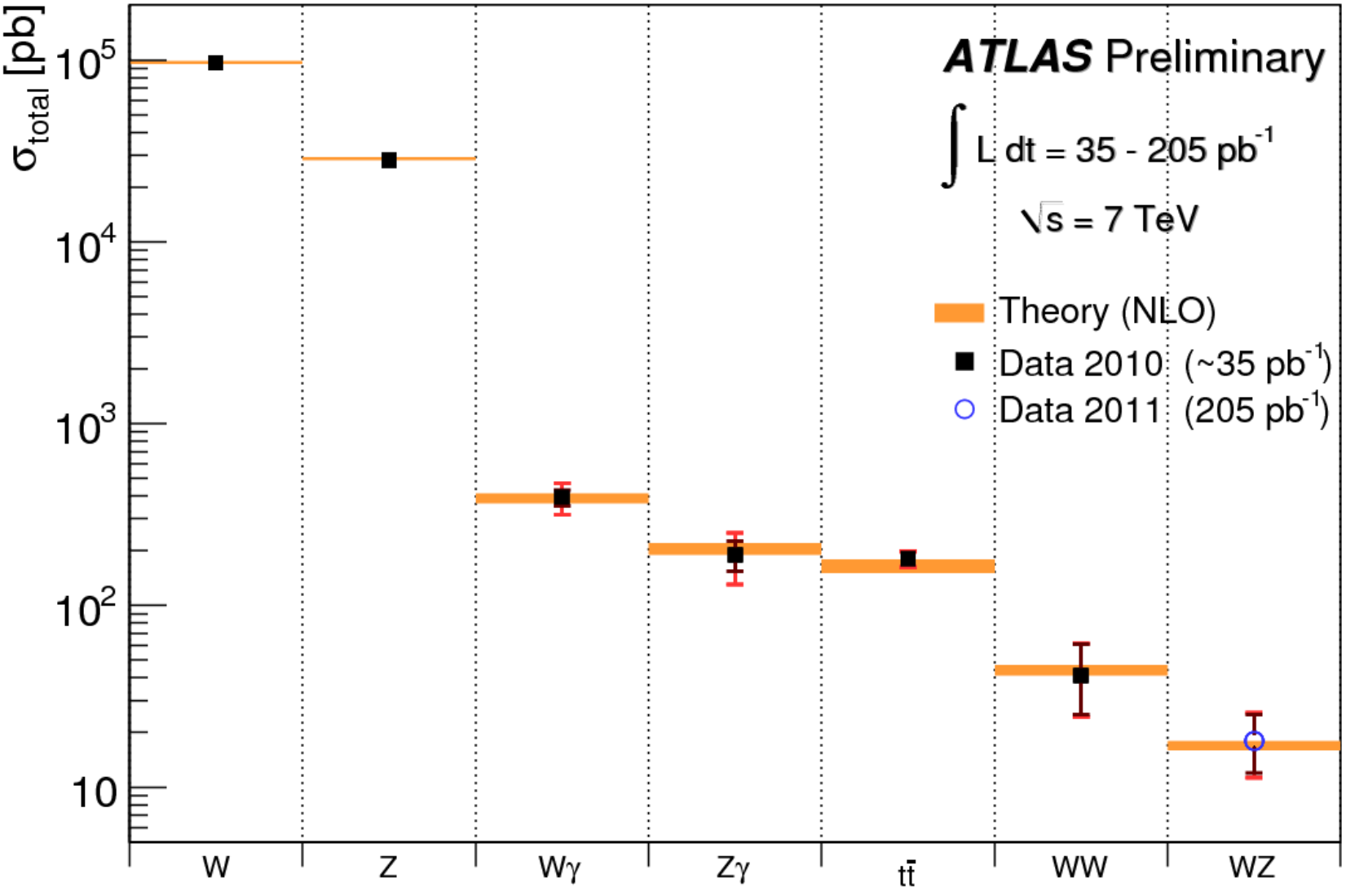
$$\sigma_t = 76^{+41}_{-21}\,pb$$

Significance

$$6.2\sigma$$

SM Cross-Section Summary

Main SM cross sections measured by ATLAS

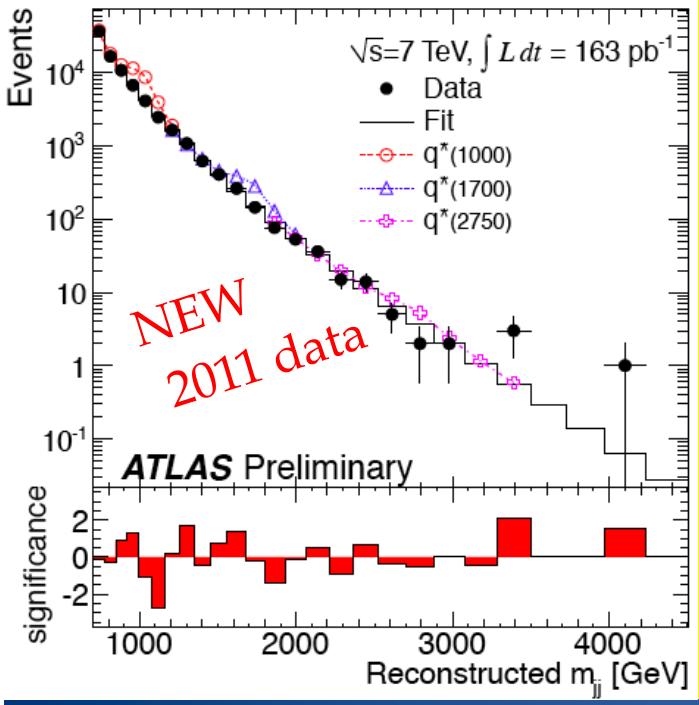


Searches: Exotics

- Report on new results with 2011 data:
  - Excited Quarks and Quark Compositeness:
    - Di-jet mass and angular distributions
  - New heavy Gauge Bosons e.g.W' and Z':
    - Transverse mass and Di-lepton mass distributions
  - T-Tbar resonances
    - Multijet, Lepton, Neutrino Invariant mass distribution
- Many more results published with 2010 data not discussed here:
  - R-S gravitons, Extra Dimensions, New Contact interactions, Lepto-quarks, Hidden Valley and many more.

Excited Quarks

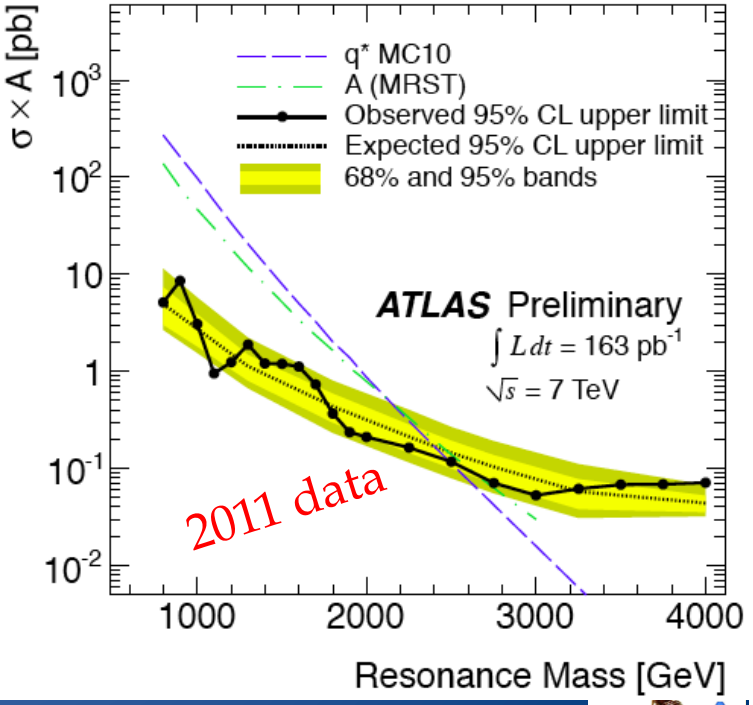
- Excited Quarks search:
- Compare bin by bin the M_{jj} distribution with a fit to data over the full M_{jj} range
- Look for bumps using the BumpHunter algorithm.
  - Select events with >= 2 Jets with P_{t1}> 150 GeV and P_{t2} > 30 GeV. Largest M_{jj} probed in central region: 4 TeV



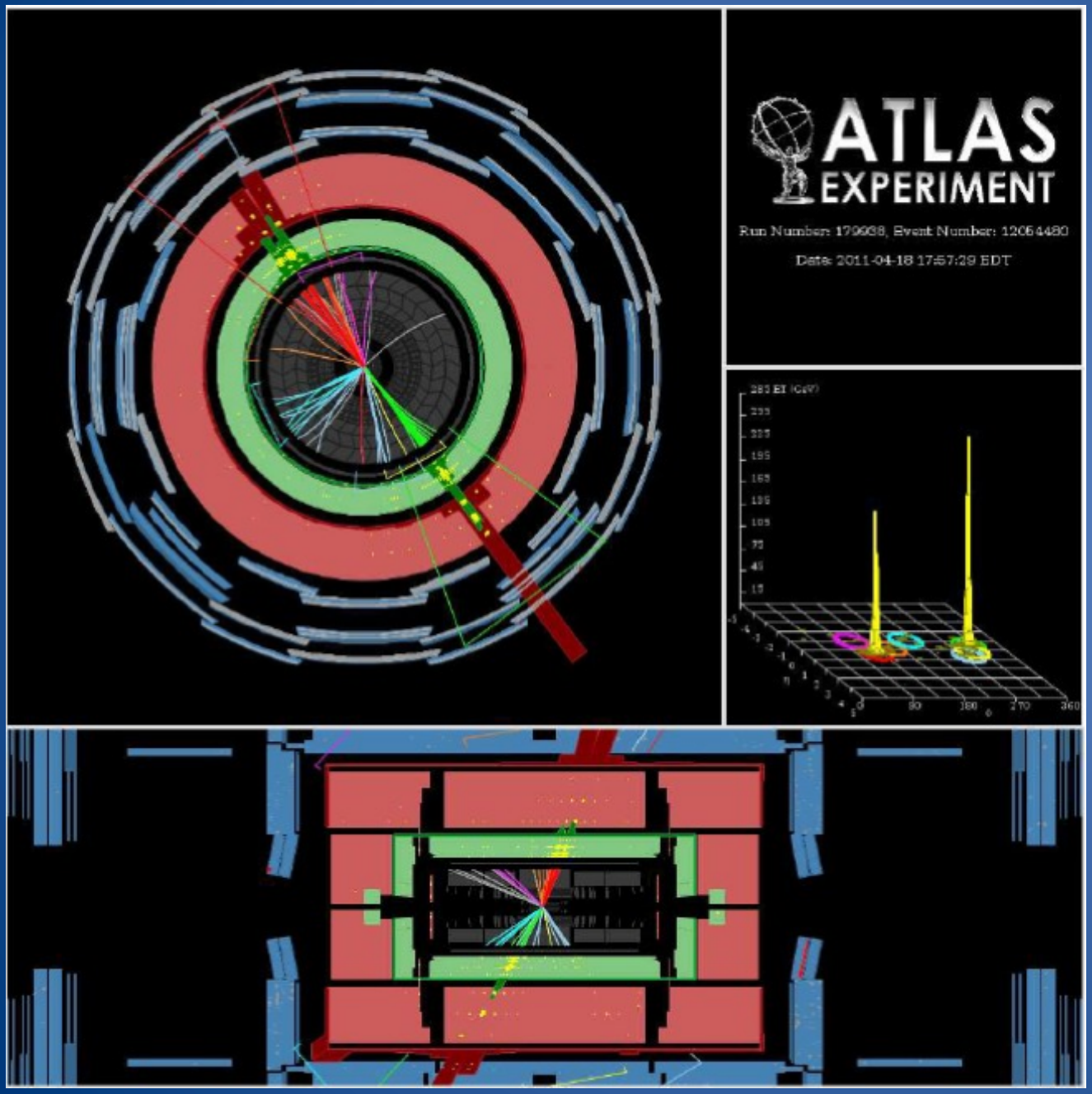
Good agreement btw. Fit and data over more than 4 order of magnitude.

No bumps observed

New Limit: Q* Mass > 2.49 TeV @95% CL



Highest Dijet Mass: M_{jj}= 4 TeV



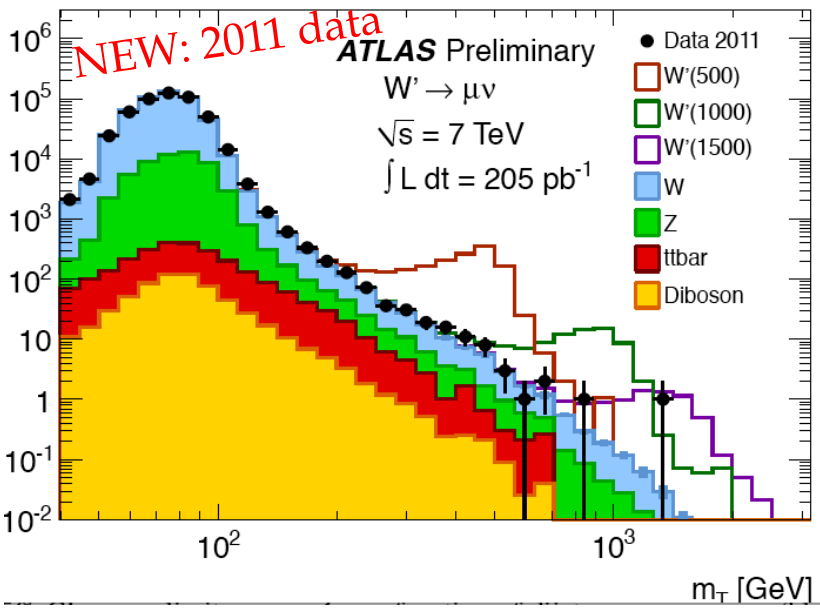
- Highest Di-Jet mass in central region
- M_{jj}=4.04 TeV
- P_t^1= 1850 GeV
- P_t^2=1840 GeV
- η^1= 0.32
- η^2=-0.53

New Heavy Bosons: W'->μν

- W' search based on the transverse mass spectrum

$$m_T = \sqrt{2 p_T^l E_T^{miss} (1 - \cos\phi_{l\nu})}$$

- Need to understand Missing Et and Muons at very high momentum
- Main background:
  - W
  - Z (if one lepton is missed)
  - Top and Di-Boson
- Quoted limits for W' and Z' are obtained in the SSM model with SM couplings for the W' and Z'

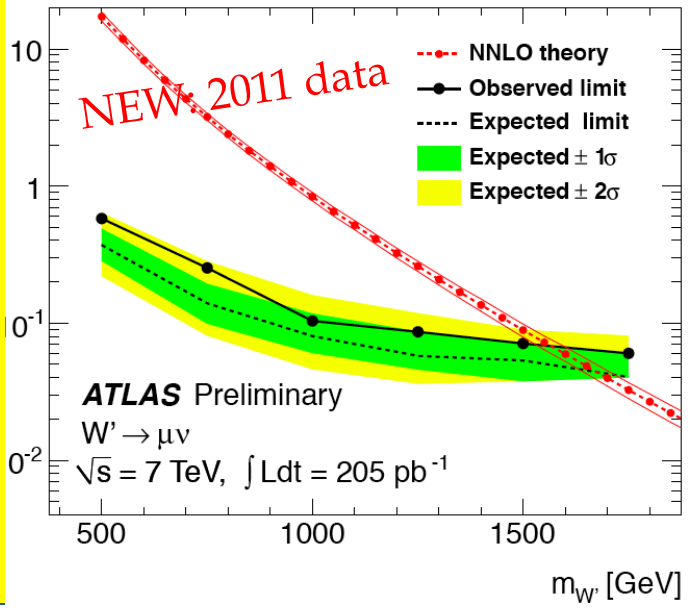


No significant excess over SM background

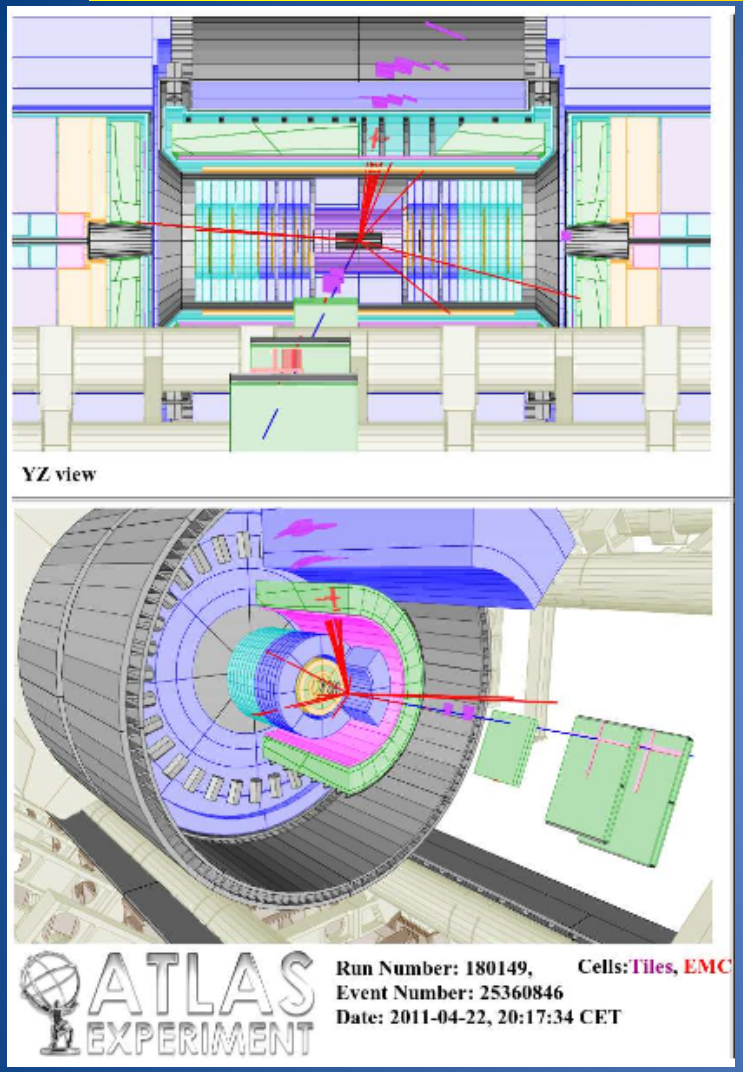
Highest M_T 1.35 TeV

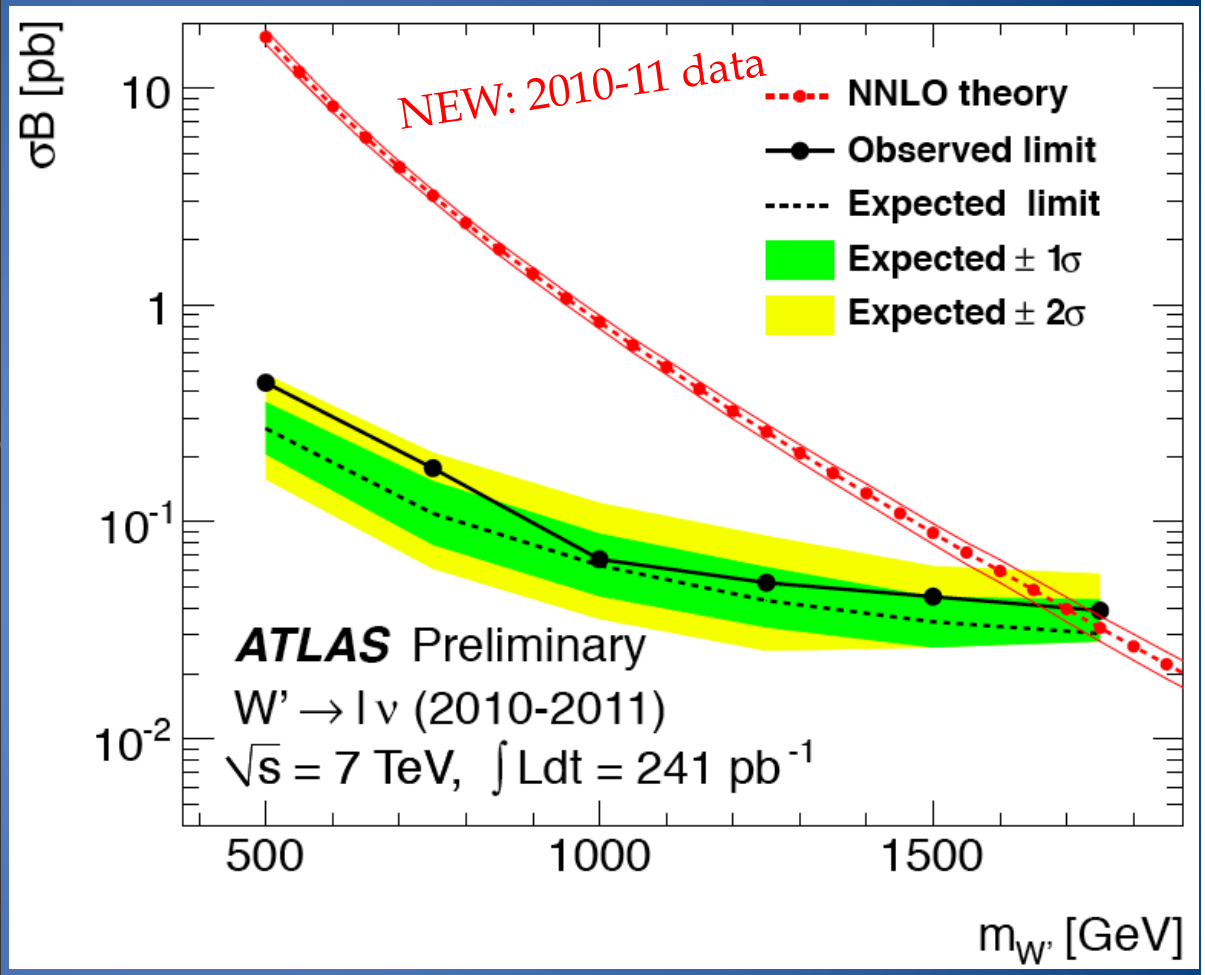
New Limit:

$M_{W'} > 1.57$ TeV 95% CL 1.68 exp



W'->μν:Highest M_T Candidate 1.35 TeV

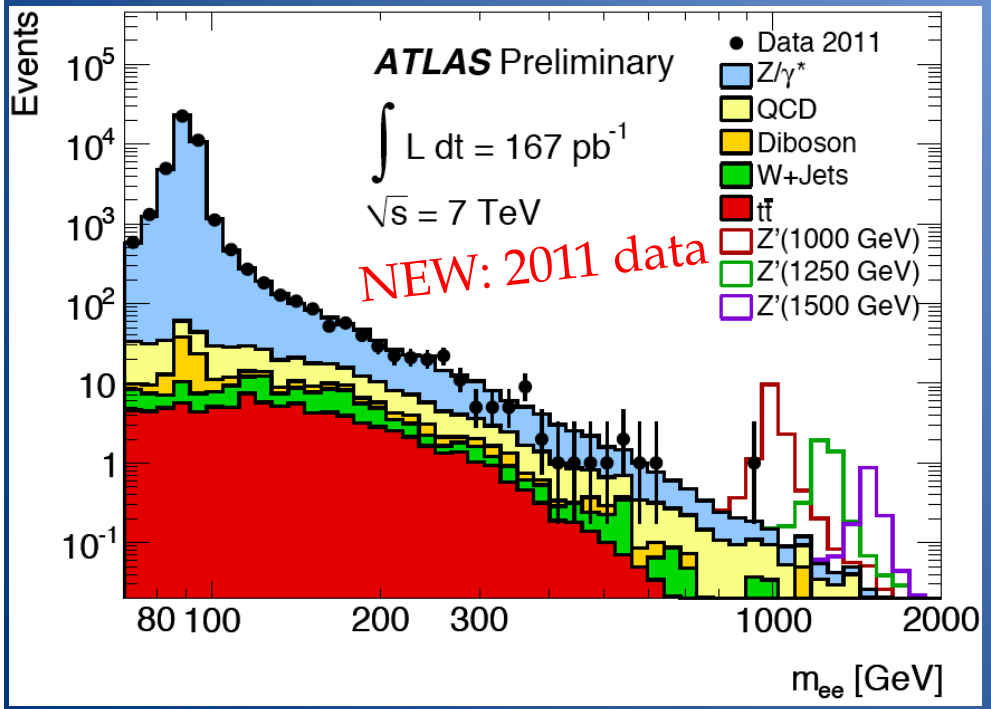


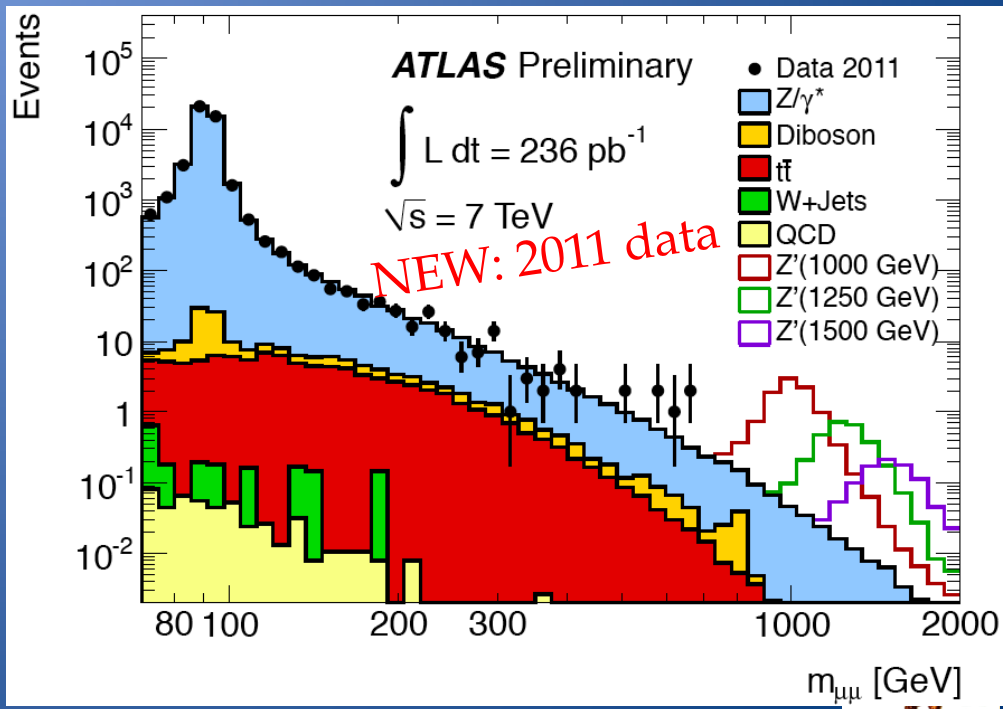


- Limit improved combining the 2010 electron and muon results with the 2011 muon result
  - $M_{W'} > 1.70$ TeV @ 95% CL (1.77 expected)

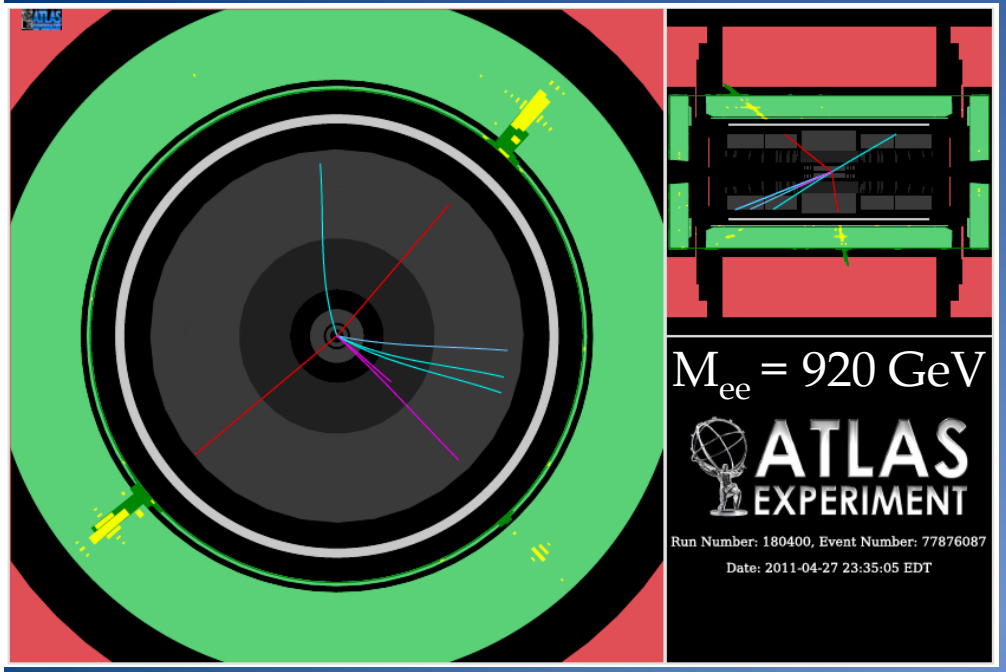
New Heavy Bosons: Z'->μμ, Z'->ee

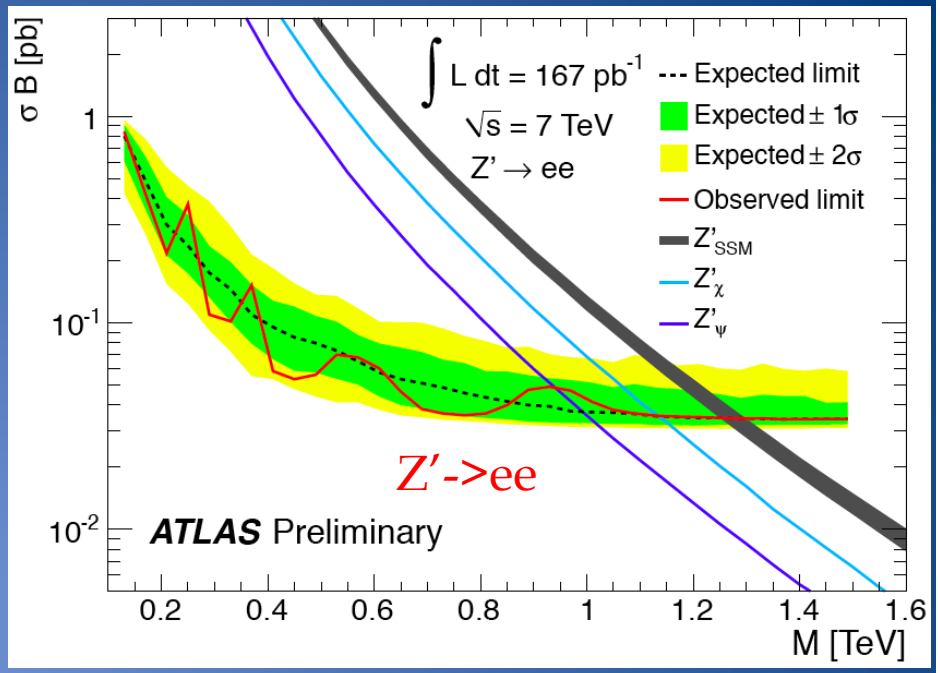
- Search for narrow di-lepton resonances
- Selection:
  - Two Isolated, High P_T Electrons or Muons :
  - $E_T(e)>25$ GeV, $P_T(\mu)>25$ GeV
- Main backgrounds:
  - Drell-Yan, W, Top (estimated via MC), QCD fakes (data-driven)





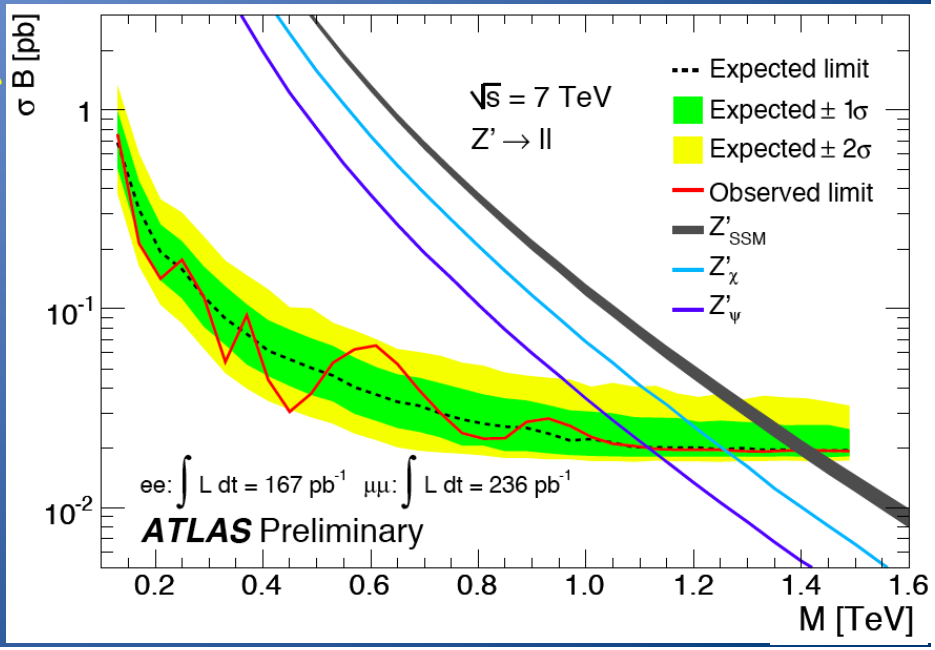
Z'->μμ, Z'->ee: New Limits





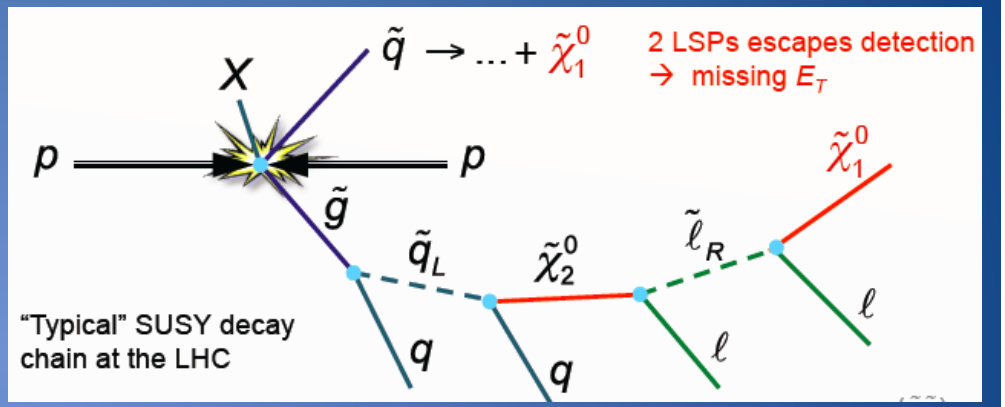
- Good agreement between Data and background expectations
- SSM Z' lower limits
  - Electron Chan. > 1.27 TeV (1.27)
  - Muon Chan. > 1.22 TeV. (1.23)
  - e-μ Combined > 1.41 TeV (1.48)

Combined limit



Still desperately seeking SUSY

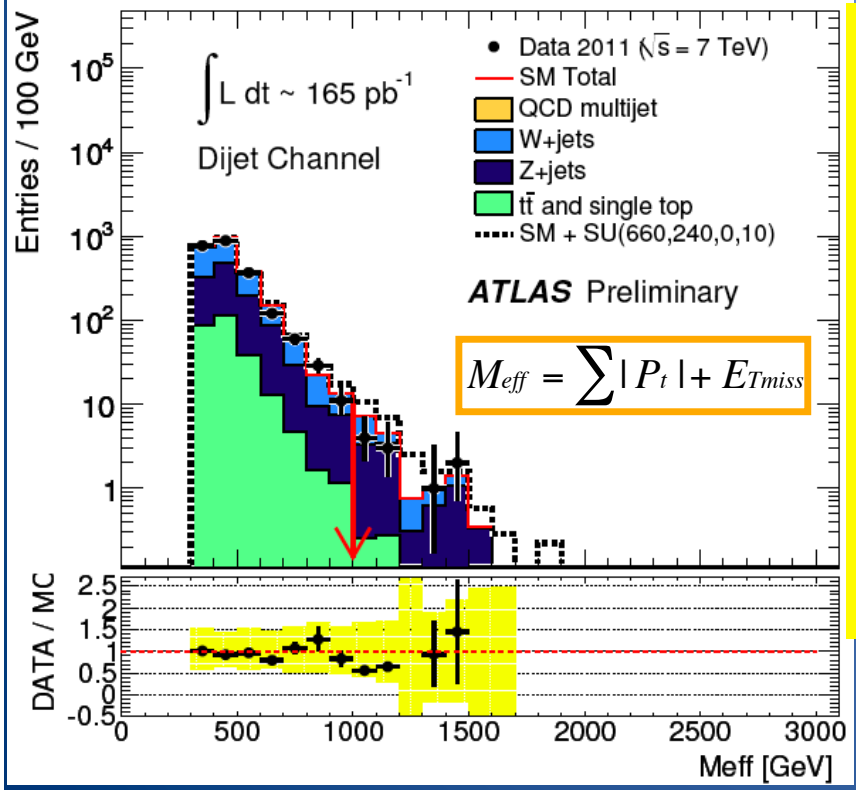
- Search for SUSY particles in many different final states all including MET
  - Jets+ MET
  - Leptons + Jets + MET
  - B-jets + MET
  - Di-leptons + MET
  - Multileptons+ Jets+ MET



- Incomplete reconstruction of events
  - SUSY evidence from tails of distributions
  - Crucial to understand Backgrounds and experimental tails

Jet+ Missing Et

- Search for Squarks and Gluinos produced in pairs (R-parity conserving models) decaying in purely hadronic final states + MET : 2, 3 , 4 Jets + MET
  - squark->$q\chi^0_1$, $\hat{g}$-> $qq\chi^0_1$ (χ^0_1 produces the E_{Tmiss})
  - M_{eff} distributions compared with data driven BKG
  - BKG: QCD, W+Jets, Z+Jets, Top



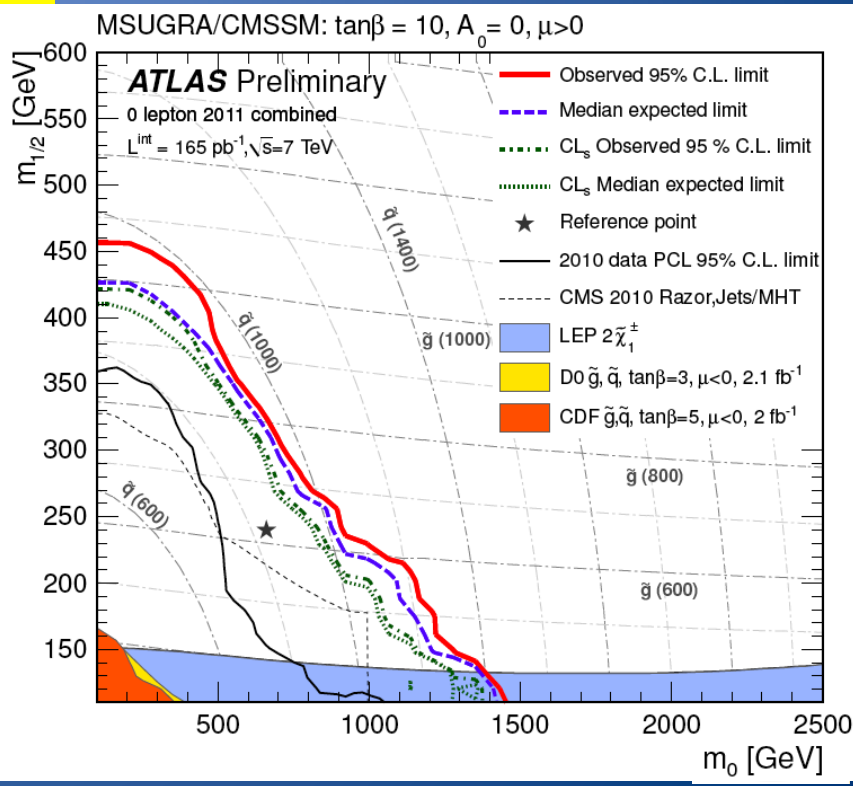
In **MSUGRA/ CMSSM** Exclude

$m_{1/2}$<455GeV

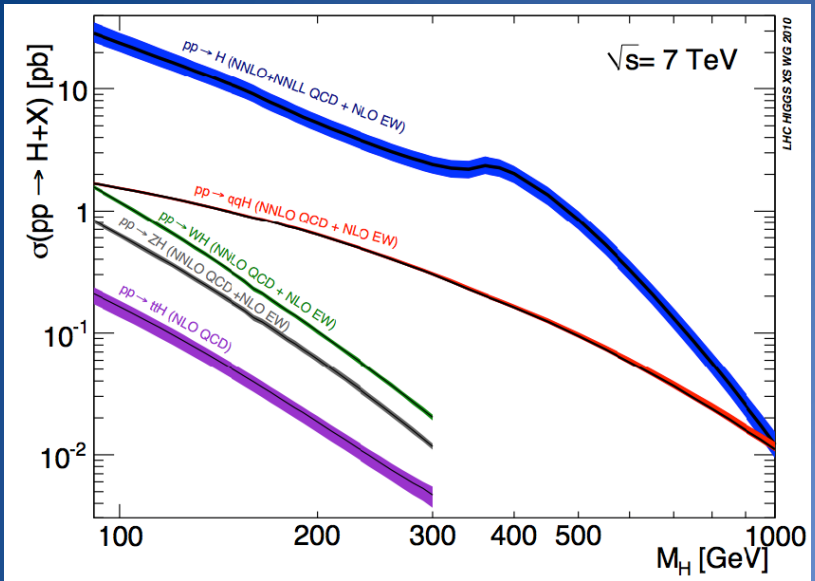
and

For $M_s=M_g$ M_s< 950GeV

Comb. Excl. limit in m_0-$m_{1/2}$ plane



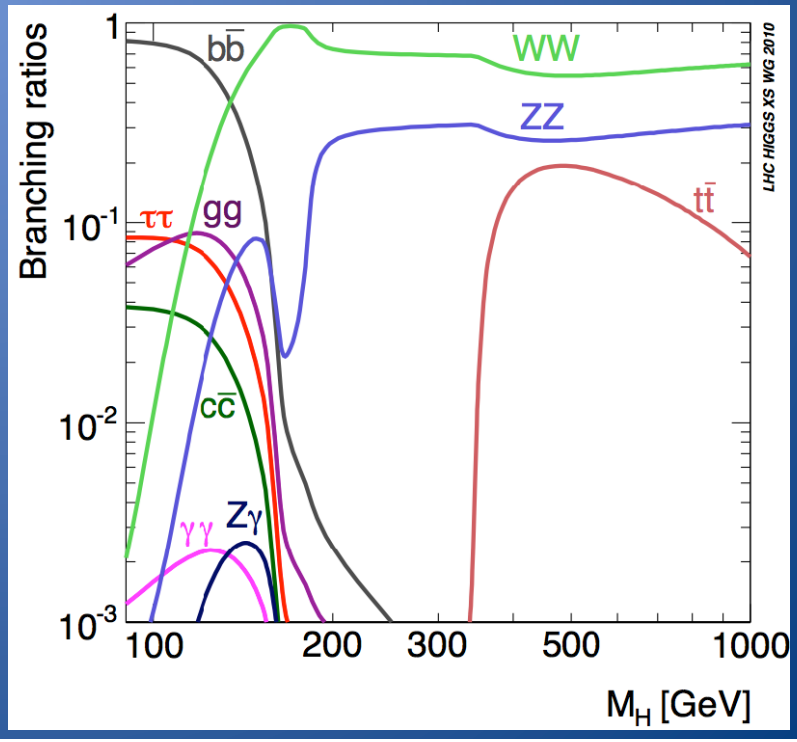
Searches: Higgs



- Gluon-Gluon Fusion is the dominant production mechanism at LHC
  - Known at NNLO
  - Cross Section uncertainty O(15%)
- Vector Boson Fusion (VBF) ≈ 1 order of magnitude smaller
  - Known at NLO
  - Uncertainty O(5%)

Higgs Branching Ratios vs M_H

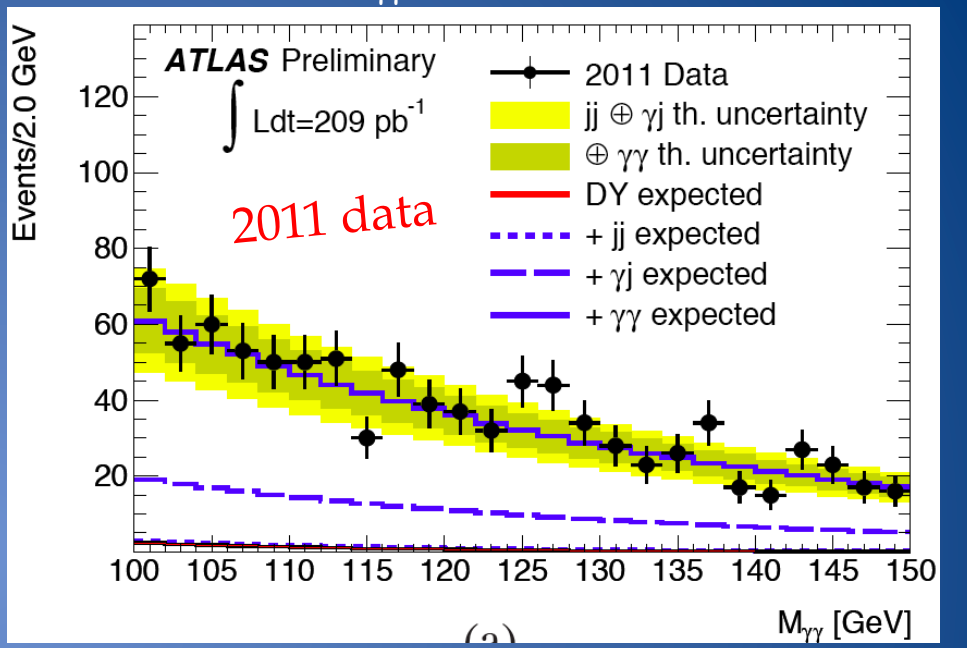
- Low Mass range (M_H<130 GeV):
  - H-> γγ, H–> ττ
- Intermediate (130<M_H<200 GeV):
  - H->WW->lνlν, H->ZZ-> 4 l
- High (M_H>200 GeV):
  - H-> ZZ->llqq,H-> ZZ->llνν, H->WW->lνqq



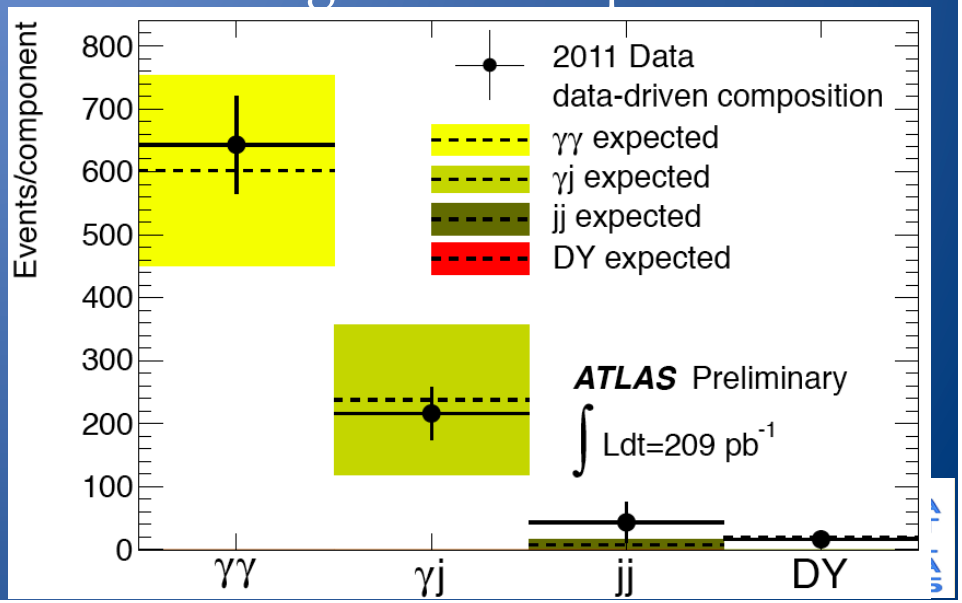
H->γγ

- Cleanest channels for very low Mass Higgs,
- Needs:
  - Good di-photon mass resolution
  - Determination of primary vertex
  - Good Photon Id.
  - γ/Jet, γ/π^0 discrimination
- Need to understand backgrounds with high precision with Data Driven techniques
  - QCD γγ production
  - γ-Jet and Jet-Jet production

$M_{\gamma\gamma}$ Spectrum

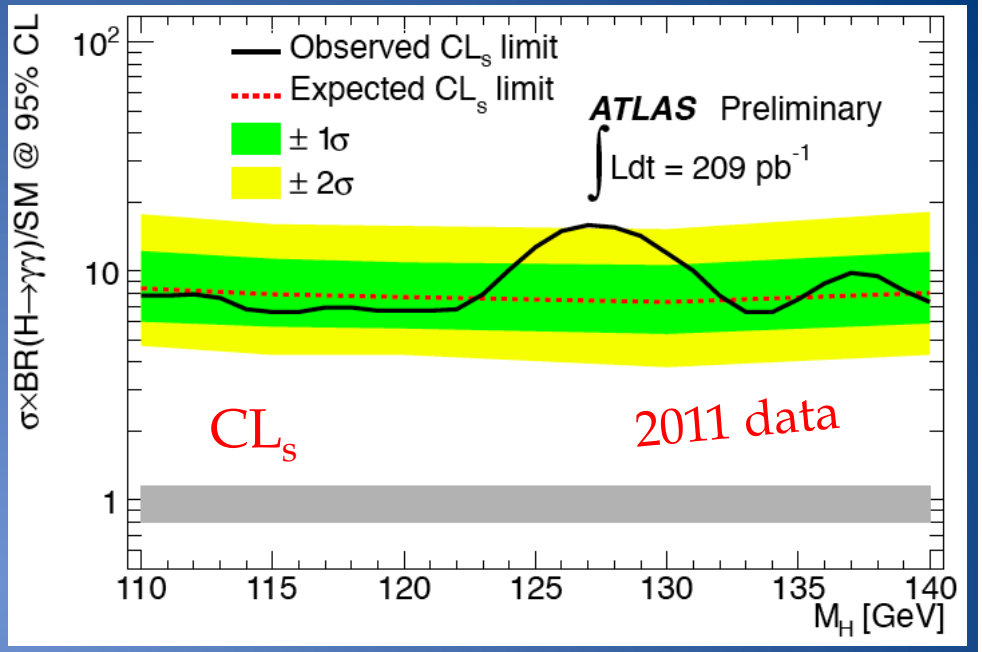


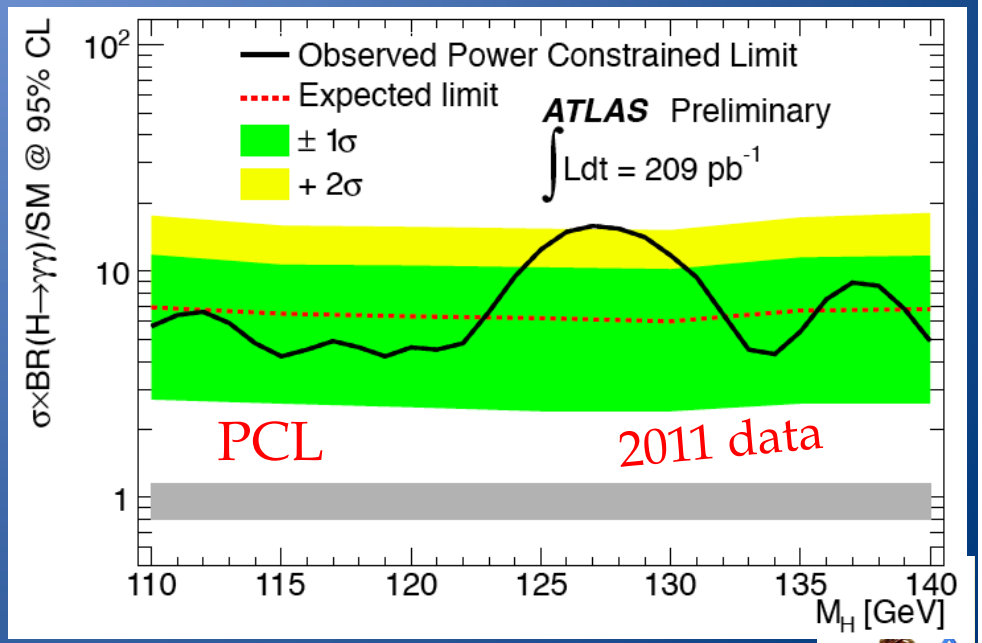
Background composition



H->γγ

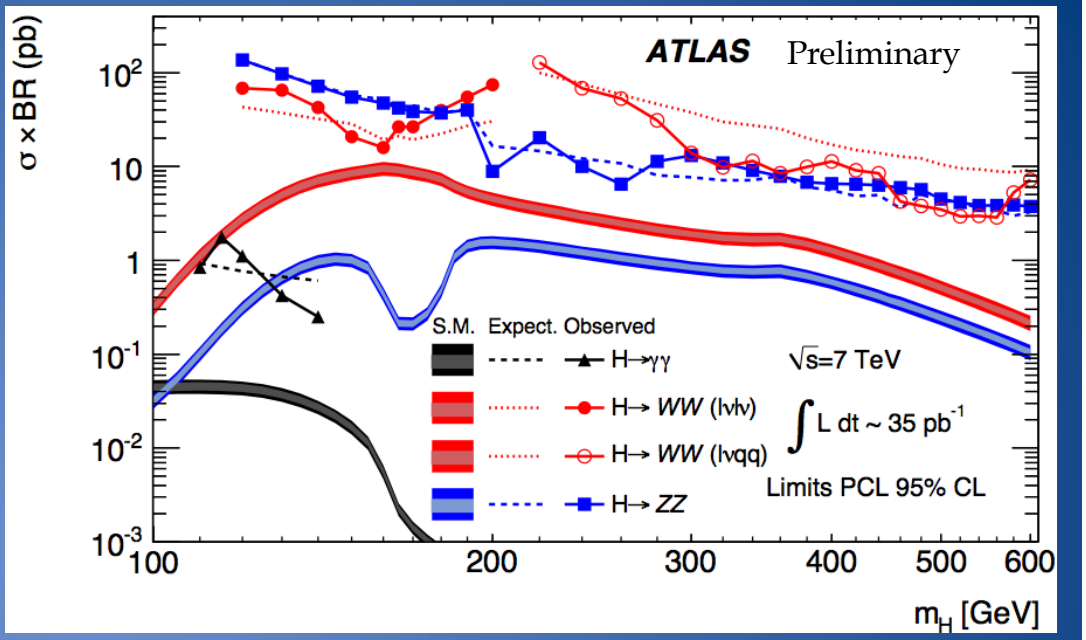
- Cleanest channels for very low Mass Higgs,
- Needs:
  - Good di-photon mass resolution
  - Determination of primary vertex
  - Good Photon Id.
  - γ/Jet, γ/π^0 discrimination
- Need to understand backgrounds with high precision with Data Driven techniques
  - QCD γγ production
  - γ-Jet and Jet-Jet production
- No significant excess seen
  - New Limit≈(4.2-15.8)×SM

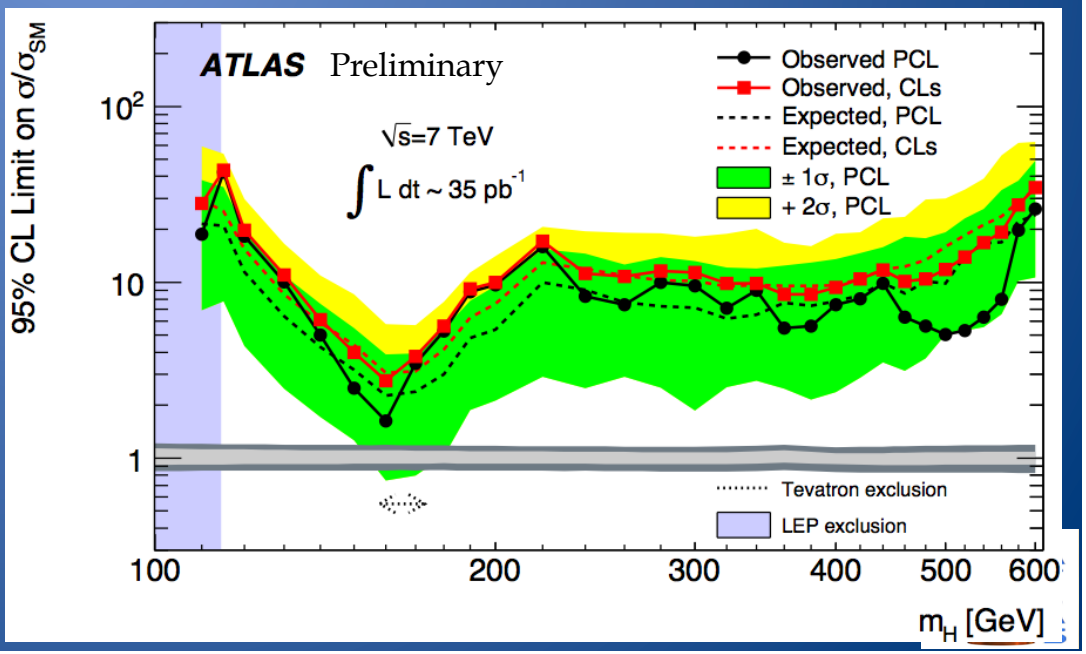




Higgs Combination

- NEW: Combination of all the different channels studied in 2010.
  - H->γγ, H->WW->lνlν,lνqq, H-ZZ(*)->4l,llνν
  - SM Higgs not yet excluded anywhere by ATLAS 2010 data
  - With 2011 data we should be able to exclude large ranges of the M_H values





Conclusions

- ATLAS is taking very good quality Data with 95% Data taking efficiency
- Data analysis is proceeding at high speed
- 36 Papers and 190 Conf Notes have been published with 2010 and 2011 data
- With this year's data we are in Terra Incognita and we are ready to harvest whatever Nature will provide us……

  ……More news ASAP

And a Big Thanks to the LHC acceller and to the LHC Computing Grid team for their excellent performances

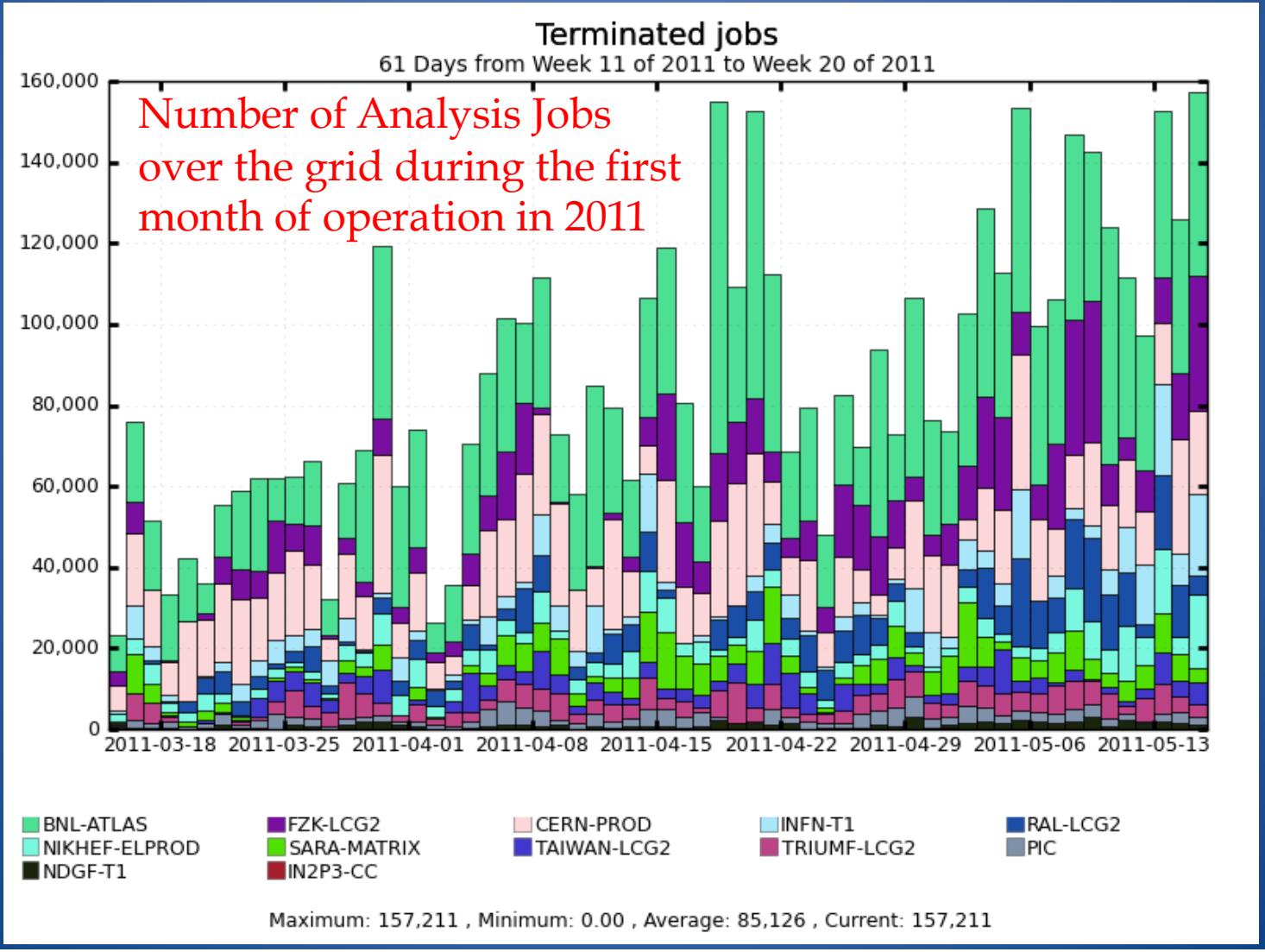
ATLAS talks in this Conference

- Results from lead-lead collisions at sqrt(s_NN)=2.76 TeV with ATLAS at the LHC
- EWK-diboson production in ATLAS
- Vector Boson production in ATLAS
- ATLAS measurement of particle multiplicities and correlations
- Multijet and the internal structure of jets measurement in ATLAS
- Diffraction and the inelastic cross section measurement with ATLAS
- Recent EVK results from ATLAS
- Recent hard QCD results from ATLAS
- Top results from ATLAS
- Quarkonium production at ATLAS
- Jet production in association with vector bosons at ATLAS
- Jet production measurement with the ATLAS detector
- Top quark pair production cross section measurement in the single lepton and di-lepton channels with ATLAS
- Search for single Top-Quark production with the ATLAS detector in pp collisions at sqrt(s) = 7 TeV
- Top quark property measurements at ATLAS
- Recent Higgs results from ATLAS
- Recent results from new Physics searches in ATLAS
- ATLAS Higgs results
- Overview of the ATLAS Supersymmetry searches with 2010 LHC data
- Searches for new particles decaying into jet pairs in 2011 ATLAS data
- Search for Susy in Jets plus missing transverse momentum final states with the ATLAS detector
- Search for Susy in lepton jets and missing transverse momentum fianl states at ATLAS
- Search for new Heavy Gauge Bosons in 2011 ATLAS data
- Search for Ttbar resonances in 2011 ATLAS data

Back-up

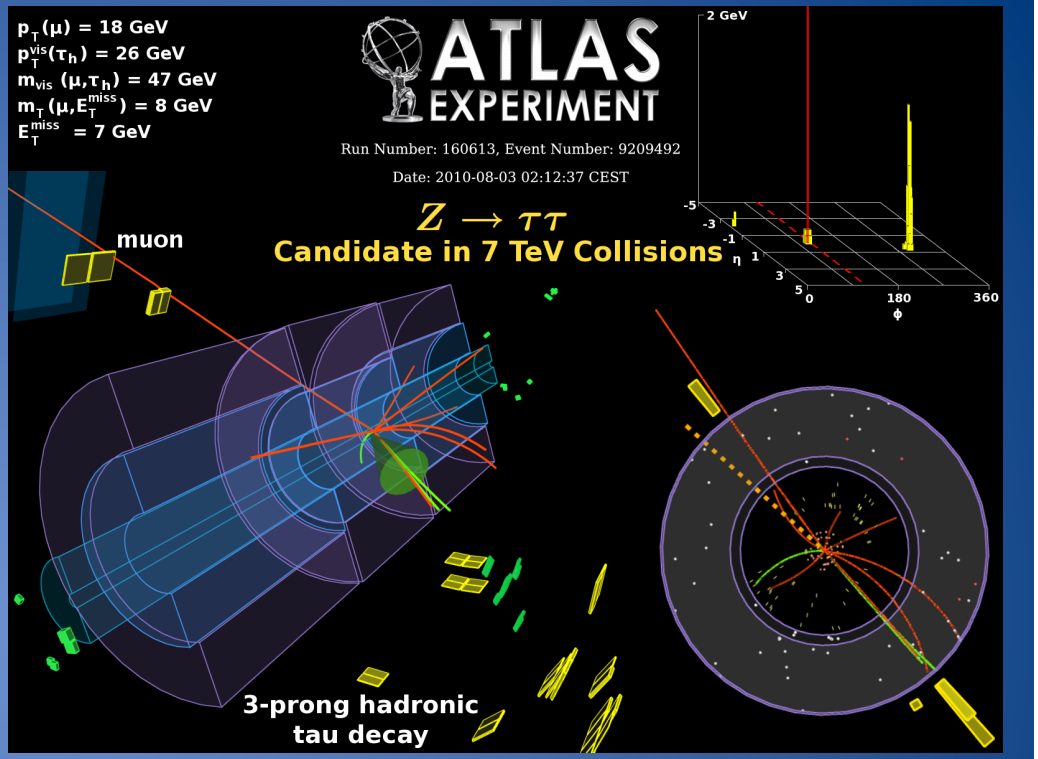
GRID – Distributed Analysis

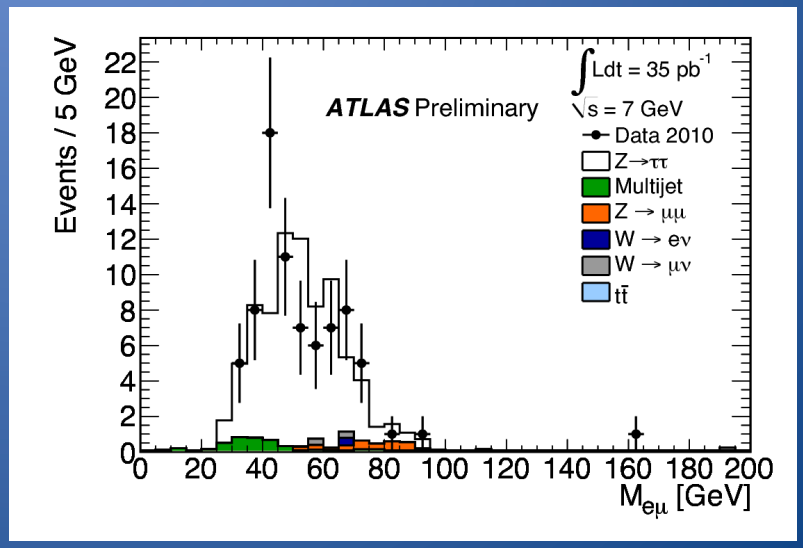
- Data Volume becomes to be Huge
- Need of efficient distribute Computing



Z-> τ_{had},τ_l

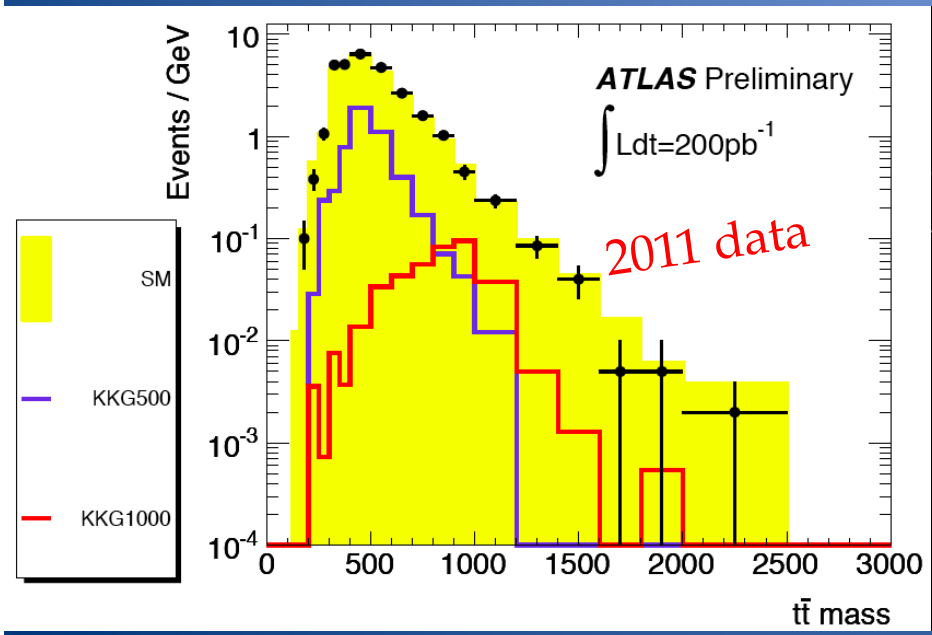
- Z-τ_{had} τ_l decays measured both in the muon and in the electron channel using 35 pb^{-1}
- 75 candidate events with 6.4 expected background events
- SM expected yield: 69+- 16





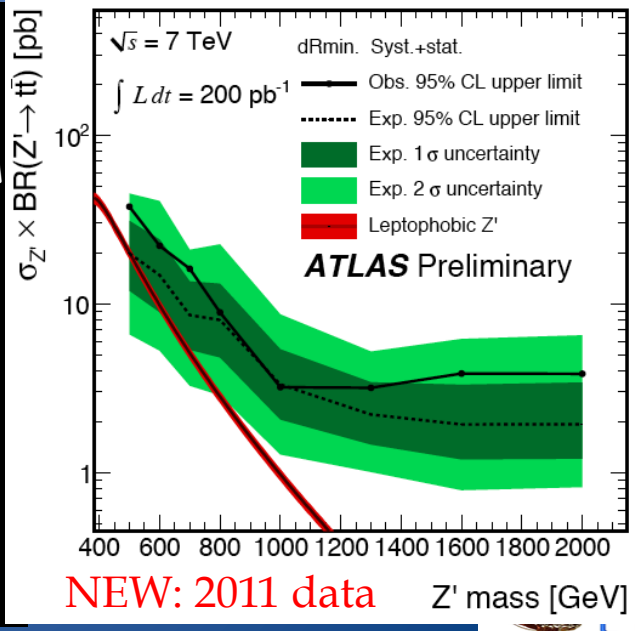
TTbar Resonances

- Search for new Heavy Particles (eg. Leptophobic Z' or Kaluza-Klein gluons) decaying in TTbar pairs
- Final states: e+Jets+E_{Tmiss} and μ+Jets+E_{Tmiss}
  - Select high momentum isolated lepton with >= 4 Jets (1 B-tagged) and large Missing Et
  - Compare the 4Jlν invariant mass distribution with SM expectations
- Background: TT, W+Jets, Z+Jets, Di-boson



For narrow Z' models limits on σxBr ranging from 47 to 4 pb @95% CL

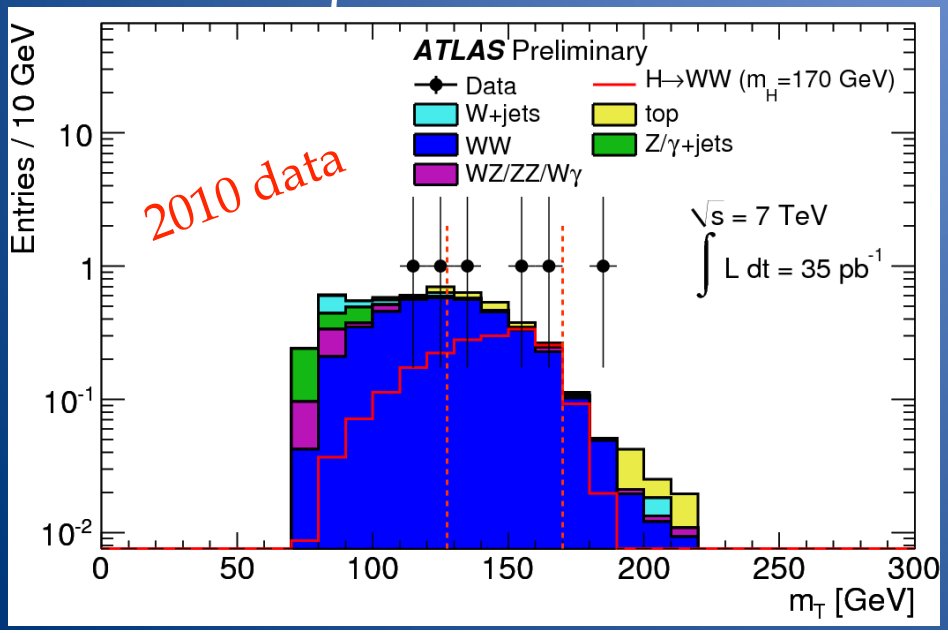
K-K Gluons masses below 680 GeV excluded at 95% CL

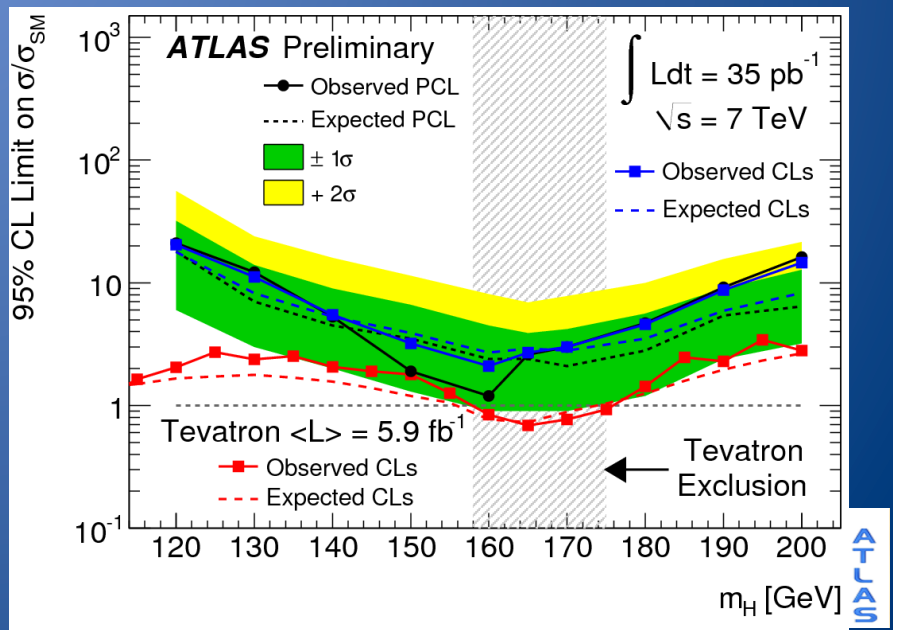


H->WW->lνlν

- Most sensitive channel for intermediate Higgs mass (120-200 GeV)
- Analysis in 3 final states
  - 2 opposite sign leptons + Etmiss+0, 1, 2 Jets
  - Disc Variable:Transverse Mass of the di-lepton, Etmiss, Delta phi ll
  - Main backgrounds: WW, Di-boson, Top and W/Z+Jets all determined with Data Driven techniques

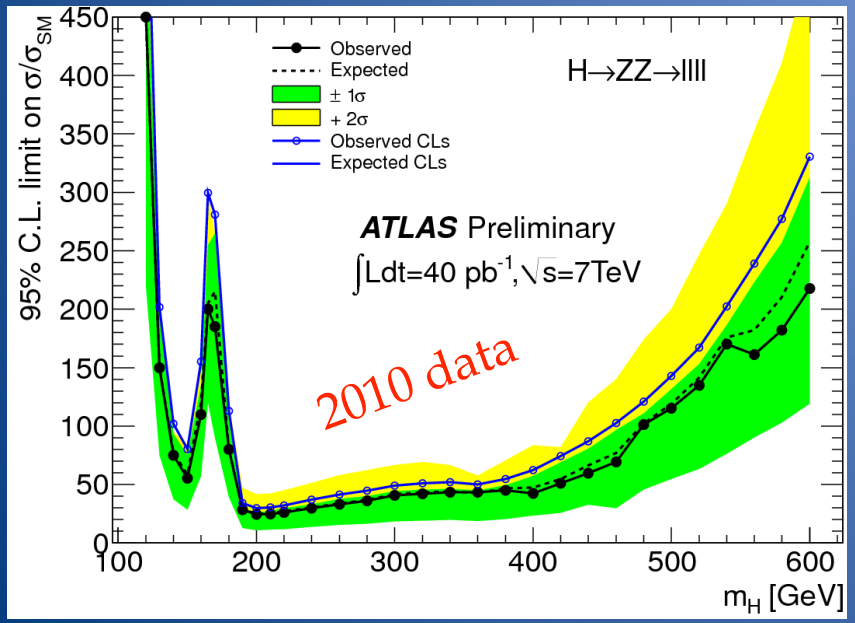
With 35 pb^{-1} ATLAS exclude 1.2 x SM cross section for a Higgs mass of 160 GeV
Very close to the TEVATRON exclusion

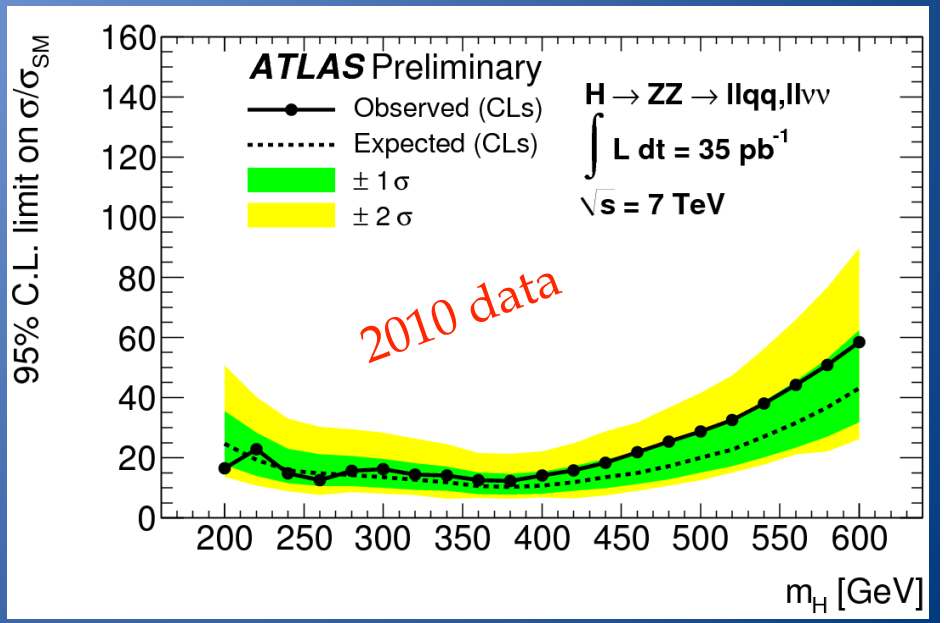




H->ZZ(*)

- Search performed in 3 different decay channels:
  - ZZ(*)-> 4 leptons, (mass range 130-600 GeV)
    - Very clean but low sensitivity
  - ZZ-> ll νν, ZZ-> ll qq, (mass range 200-600 GeV)
    - Higher sensitivity due to higher BR (x27), but more difficult topologies

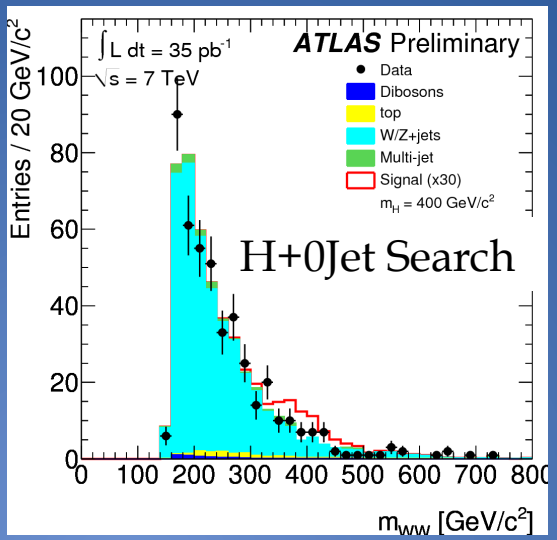


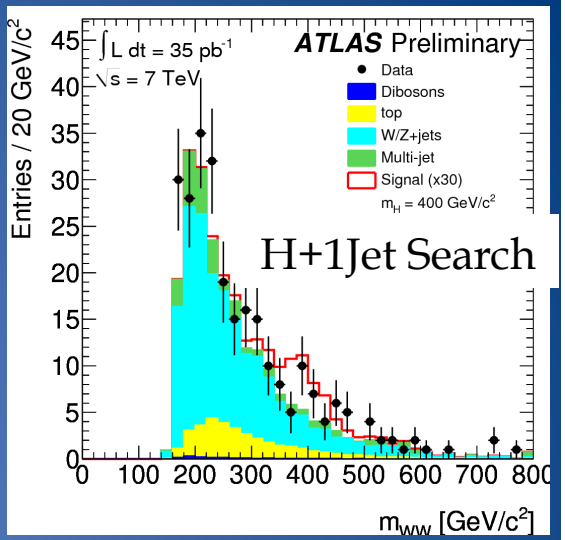


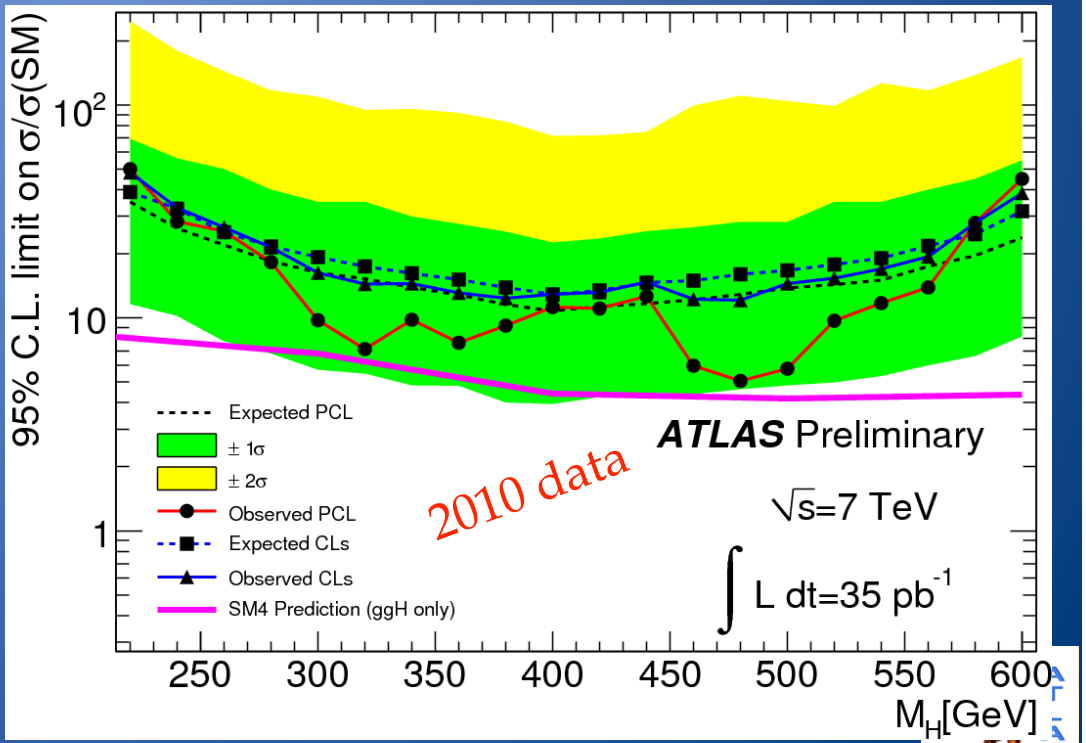
- Reach sensitivities of about X20 of standard model cross section with 2010 statistics

H->WW->lνqq

- High Mass range
- Final states include 1 electron or 1 muon + Etmiss + 2 or 3 Jets
- Reconstruct the Invariant Mass of the 2 Ws by imposing:
  - $M_{l\nu} = M_W$
- Backgrounds:
  - W/Z+Jets, Multi-Jets, Top and Di-bosons
- Limits : for M_H=400 GeV exclude Cross Sections > 12.9 SM





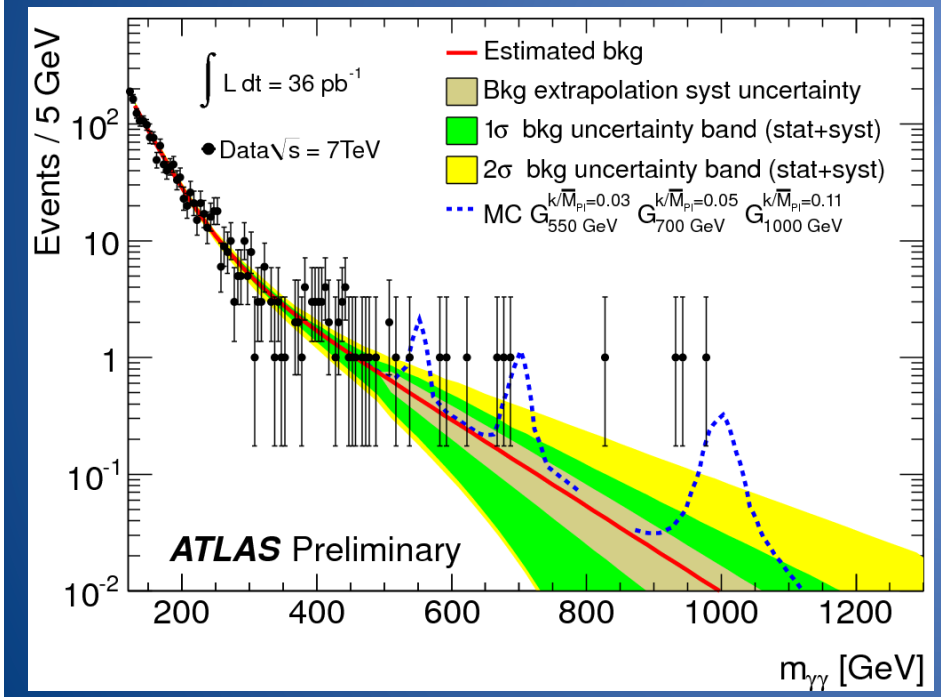


W/Z Candidates

Final State	$eee + E_{\mathrm{T}}^{\mathrm{miss}}$	$ee\mu + E_{\mathrm{T}}^{\mathrm{miss}}$	$e\mu\mu + E_{\mathrm{T}}^{\mathrm{miss}}$	$\mu\mu\mu + E_{\mathrm{T}}^{\mathrm{miss}}$	combined
Observed	2	2	2	6	12
Signal	1.32±0.09	1.76±0.10	2.48±0.11	3.52±0.13	9.08±0.22±1.26
Bkg					
ZZ	0.03±0.03	0.12±0.01	0.08±0.01	0.18±0.01	0.40±0.03±0.05
W/Z+jets	0.09±0.02	0.17±0.04	0.24±0.07	0.52±0.08	1.02±0.12±0.50
Top	–	0±0.03	–	0.35±0.18	0.35±0.18±0.05
$W/Z + \gamma$	0.14±0.14	0±0	0.07±0.07	0±0	0.21±0.15±0.07
Bkg(tot)	0.25±0.14	0.29±0.05	0.39±0.10	1.05±0.19	1.98±0.27±0.67
S/B	5.3	6.2	6.3	3.3	4.6

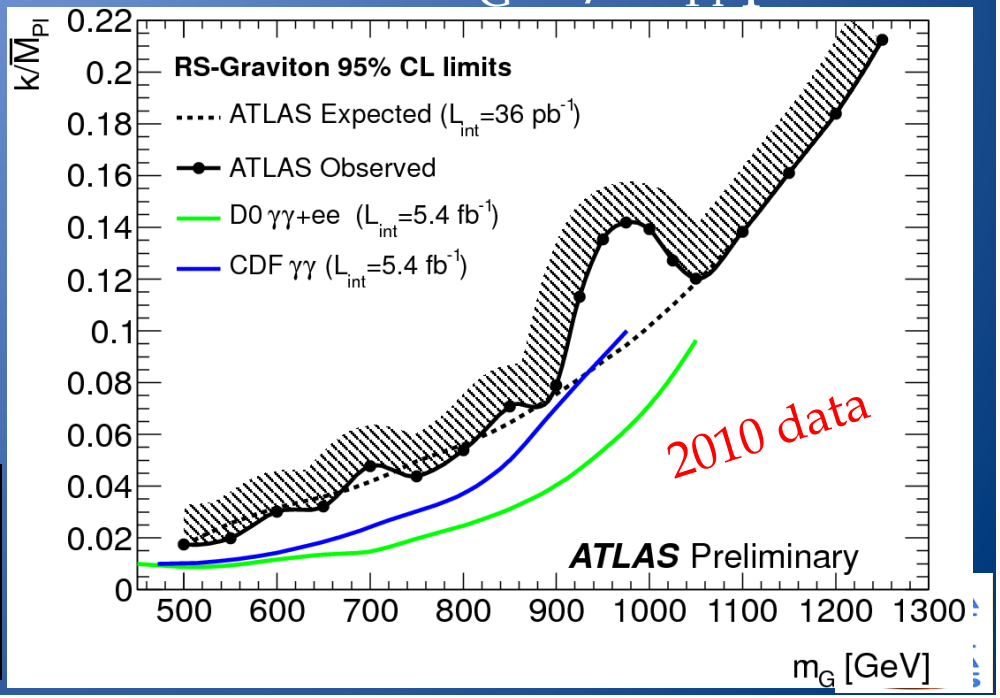
Extra-dimensions: Di-photons

- Randal-Sundrum Model predicts Graviton production with the subsequent decay in di-photons
- Look for narrow resonances in the di-photon mass spectrum
- Main background: SM $\gamma\gamma$, γ+Jet and MultiJet



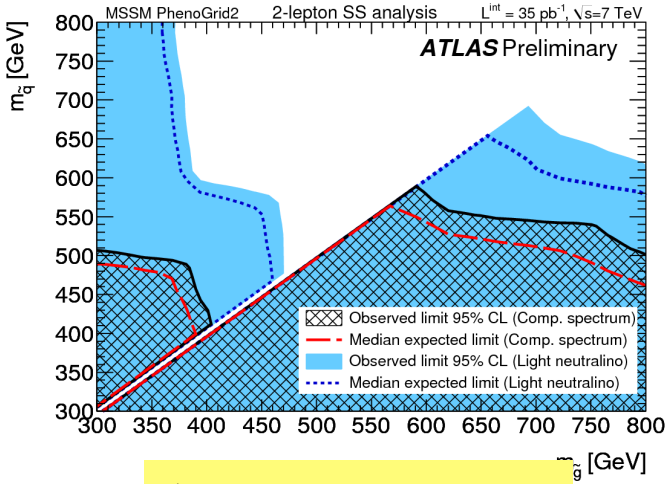
Start to be competitive with Tevatron with only 36 pb^{-1}

Limits in the M_G-K/M_{Pl} plane

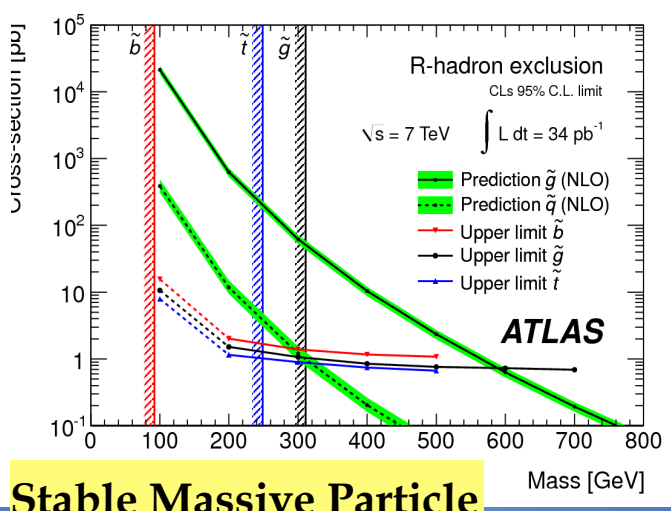


M_G > 545 GeV (k/M_{PL} = 0.02)
M_G > 920 GeV (k/M_{PL} = 0.1)

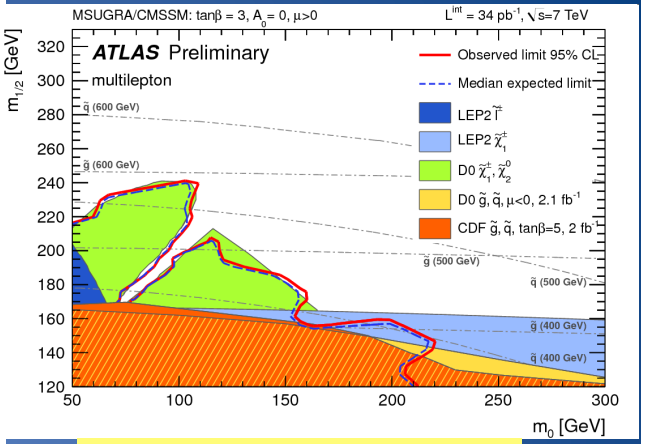
Many more SUSY results



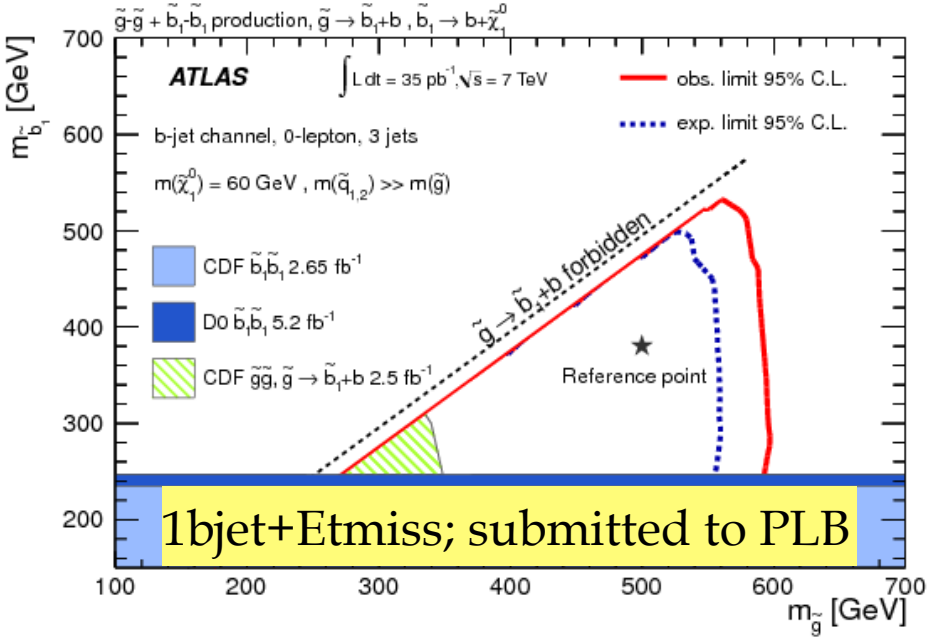
2lepton+Etmiss



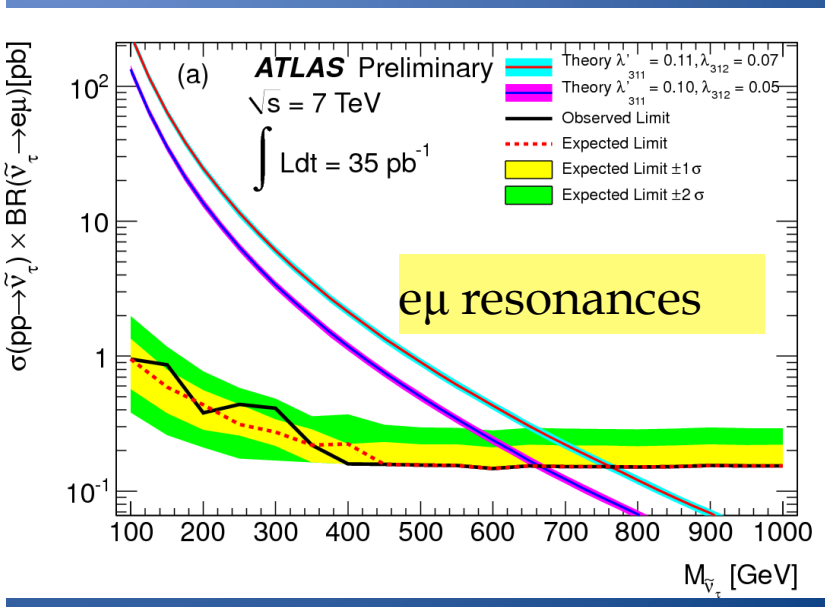
Stable Massive Particle
(1103.1984, submitted to PLB)



multi leptons;
ATLAS-CONF-2011-039



1bjet+Etmiss; submitted to PLB



eμ resonances

Data Quality

- Fraction of Good Data per detector

Inner Tracking Detectors			Calorimeters				Muon Detectors				Magnets	
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.5	99.4	100	87.5	92.4	94.5	100	100	99.0	99.9	99.8	96.8	95.1

- Data are processed at Tier0 after 36 hours needed to complete Calibrations
  - Updates on detector Calibrations/Conditions, Beam Spot and Data Quality Sign Off
  - First pass of reconstruction with well calibrated detector