ATLAS Physics Prospects for 2010-2011

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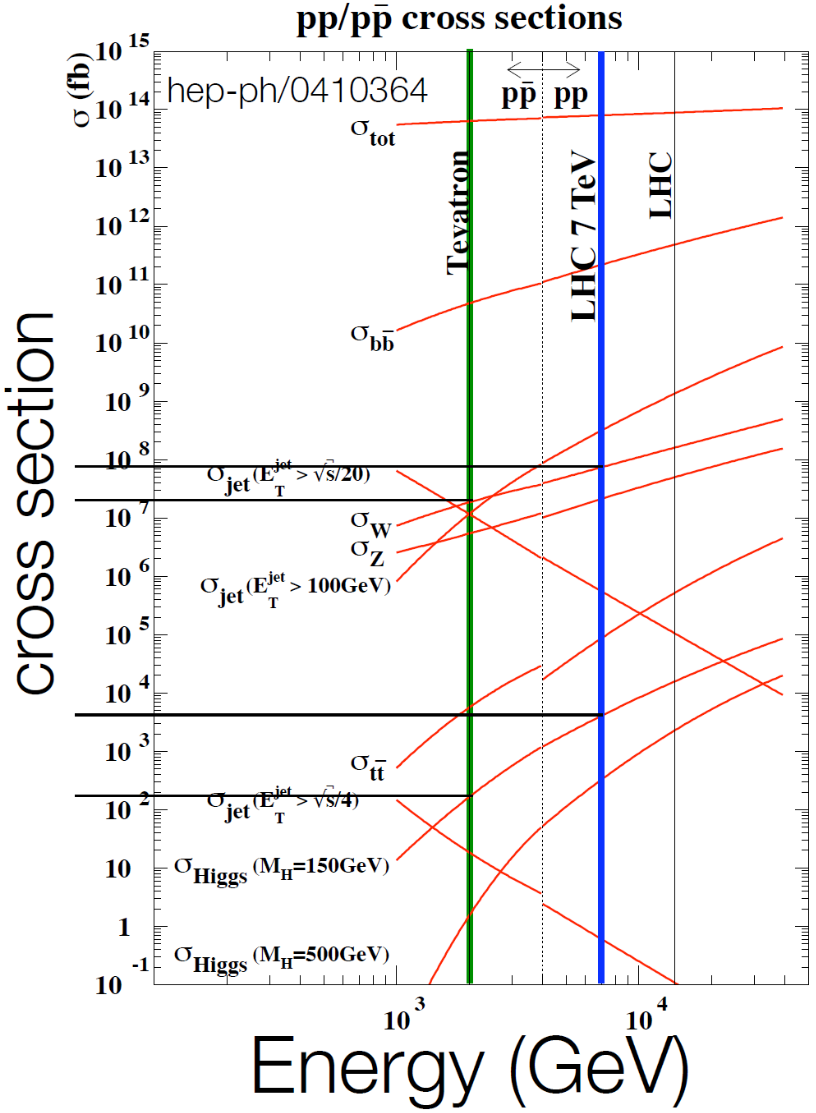
on behalf of ATLAS collaboration

see also Bruse Melado report

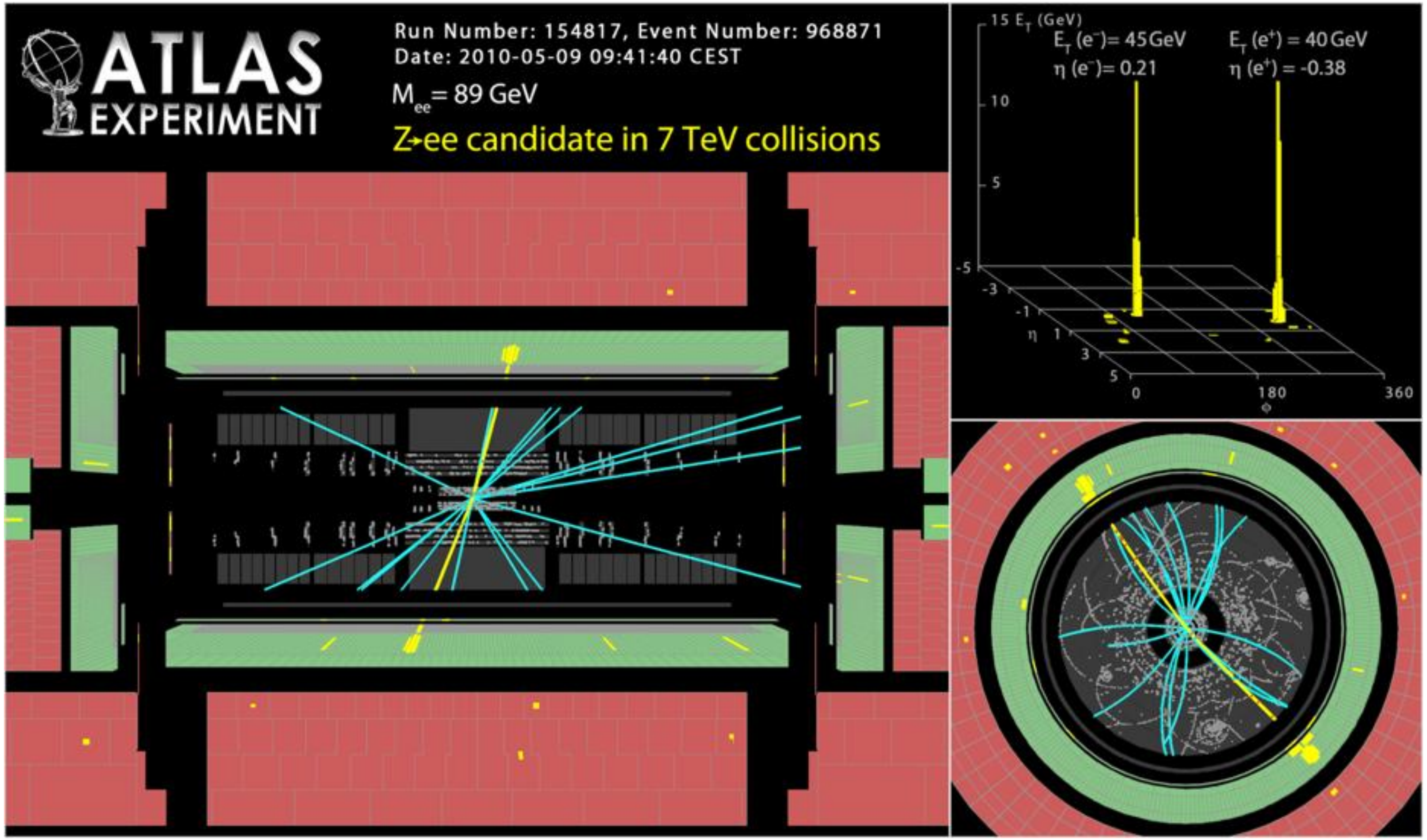
Outline:

- W and Z production
- Early B-physics
- Top
- Higgs
- Exotics
- SUSY

We assume ~50 pb^{-1} in 2010 and ~1 fb^{-1} by the end of 2011.



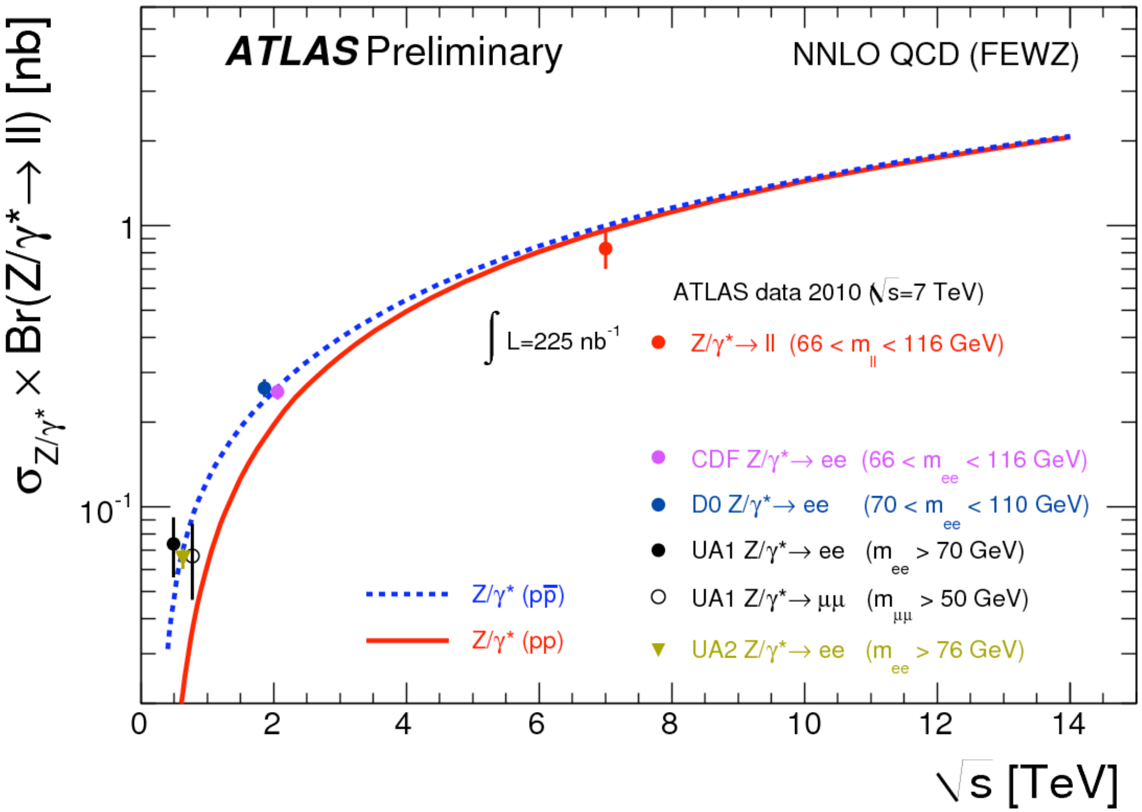
Z production

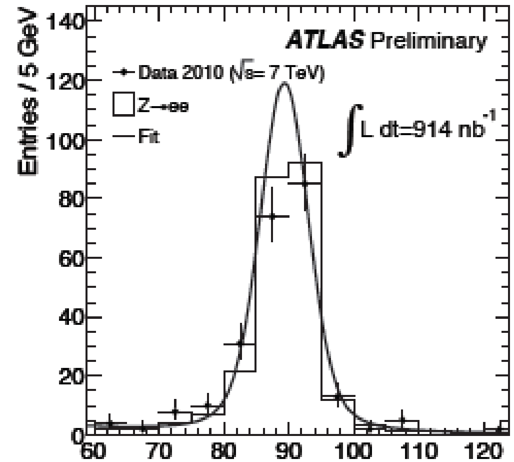


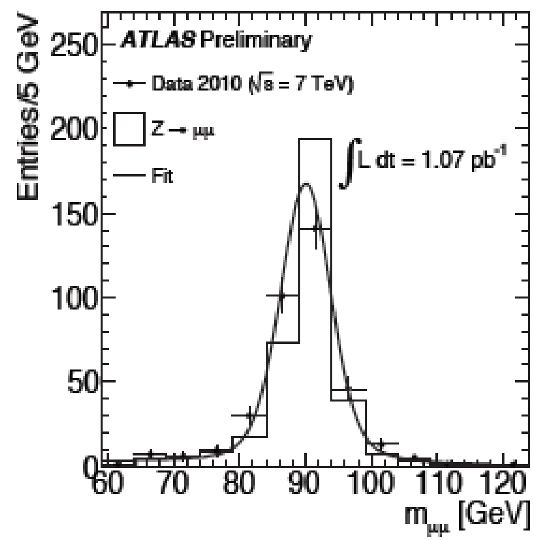
- **Z → ll is gold-plated process to calibrate the detector to the ultimate precision (E and p scales and resolutions in EM calo, tracker, muon spectrometer; lepton identification, …)**
- **dominant background to searches for New Physics**

Z production

For more details see report of G.Salamanna



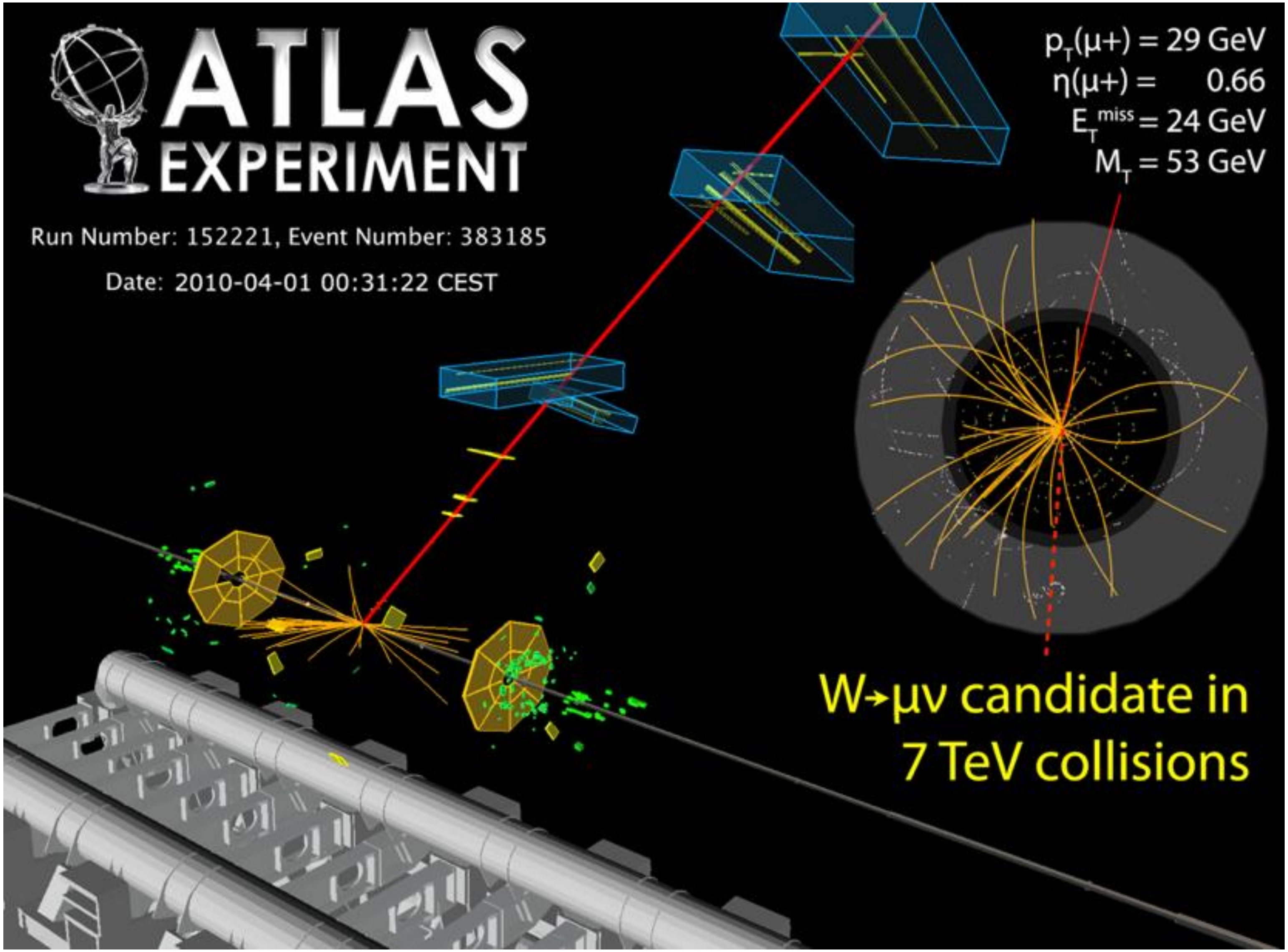




Theory: σ NNLO (γ*/Z → ll) ~ 0.99 nb

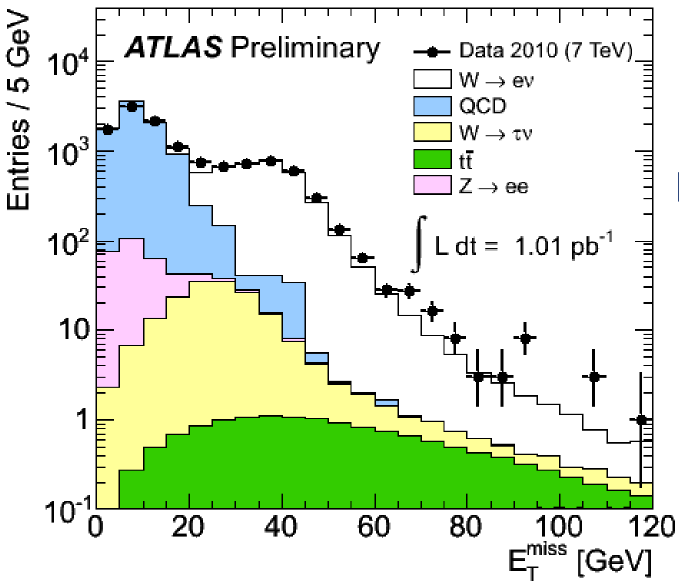
- **σ (Z → ll) = 0.83 ± 0.07 (stat) ± 0.06 (syst) ± 0.09 (lumi) nb**
- **σ (Z → ee) = 0.72 ± 0.11 (stat) ± 0.10 (syst) ± 0.08 (lumi) nb**
- **σ (Z → μμ) = 0.89 ± 0.10 (stat) ± 0.07 (syst) ± 0.10 (lumi) nb**

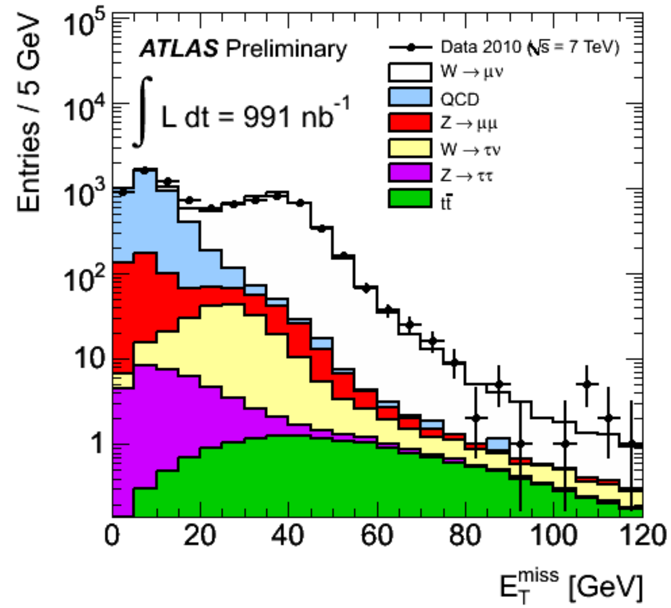
W production

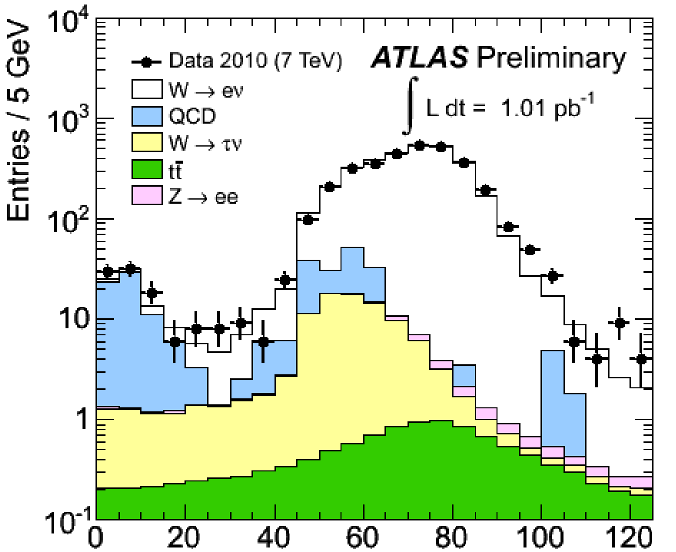


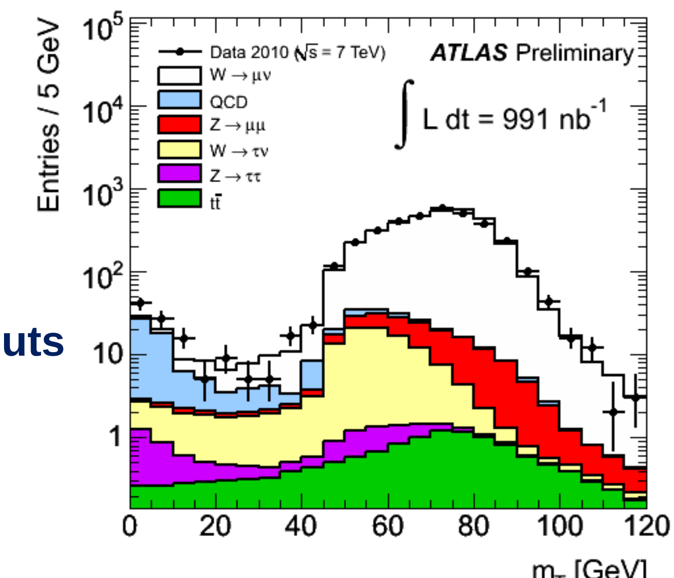
W production

Before ETMiss cut







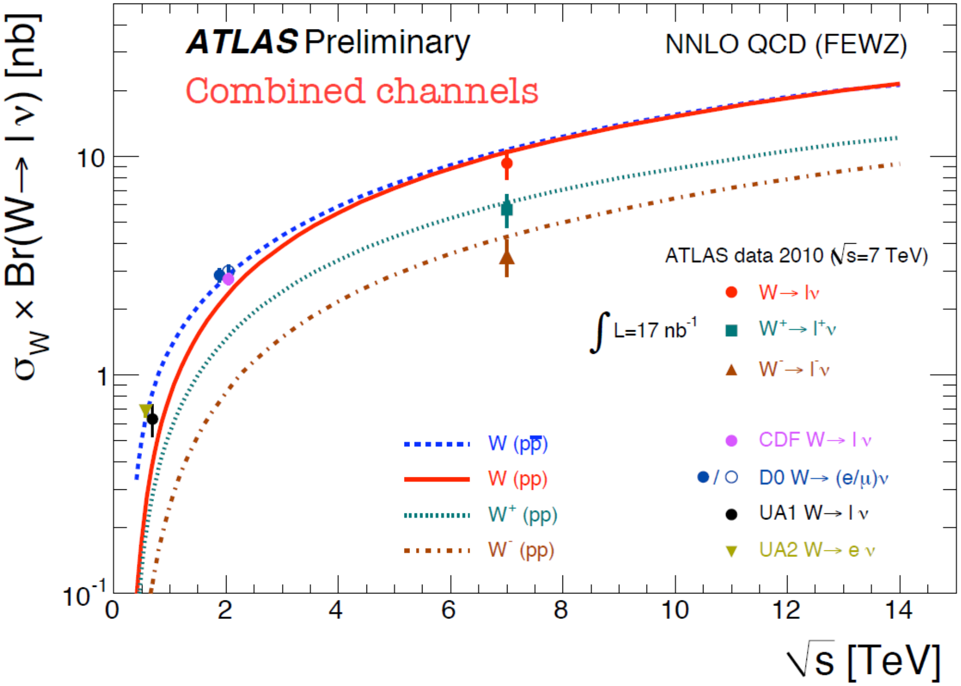


After all selection cuts

W cross-section

Theoretical prediction (NNLO) with 4% uncertainty:

$\sigma_{W\to l\nu}$ =10.64 nb $\sigma_{W-\to l\nu-}$=6.16 nb $\sigma_{W+\to l\nu+}$=4.30 nb



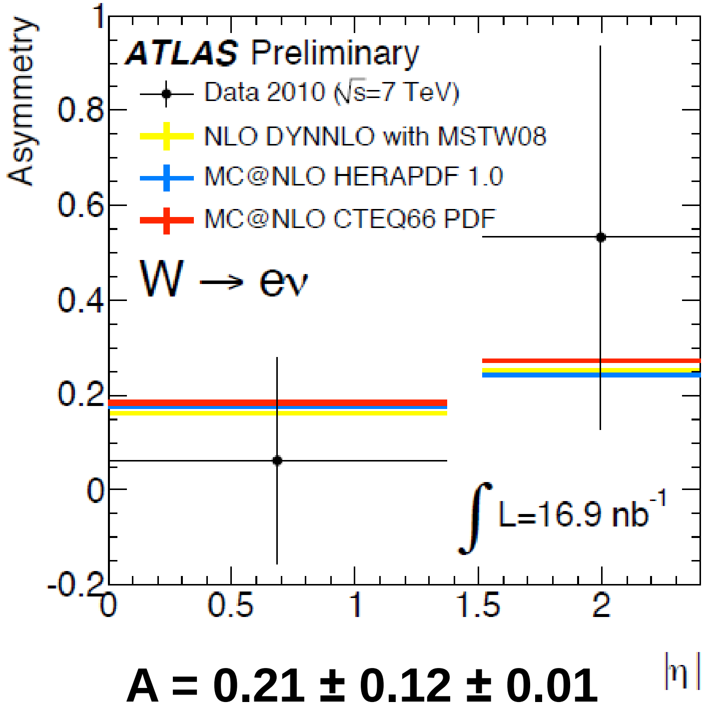
σ (W → lν) = 9.3 ± 0.9 (stat) ± 0.6 (syst) ± 1.0 (lumi) nb

σ (W → eν) = 8.5 ± 1.3 (stat) ± 0.7 (syst) ± 0.9 (lumi) nb

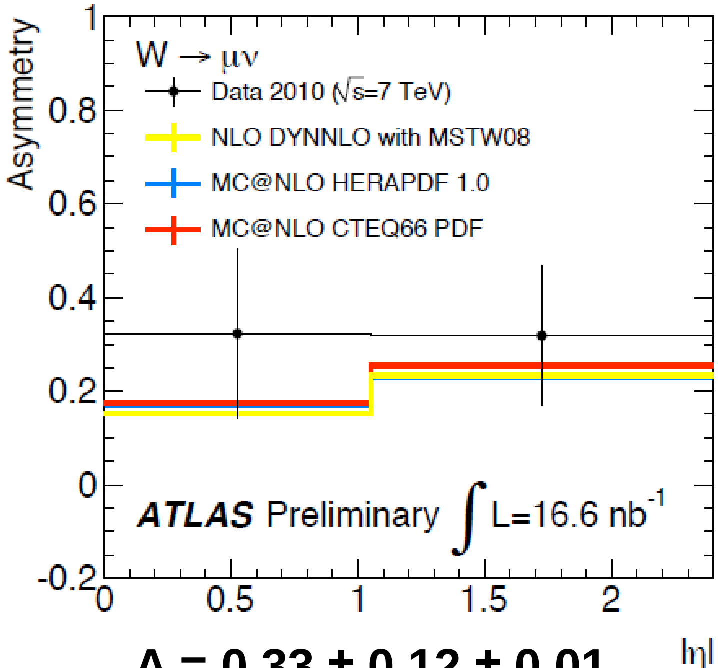
σ (W → μν) = 10.3 ± 1.3 (stat) ± 0.8 (syst) ± 1.1 (lumi) nb

W charge asymmetry

$$A = \frac{\sigma(W \to \ell^{+}\nu) - \sigma(W \to \ell^{-}\nu)}{\sigma(W \to \ell^{+}\nu) + \sigma(W \to \ell^{-}\nu)} \neq 0$$



A = 0.21 ± 0.12 ± 0.01

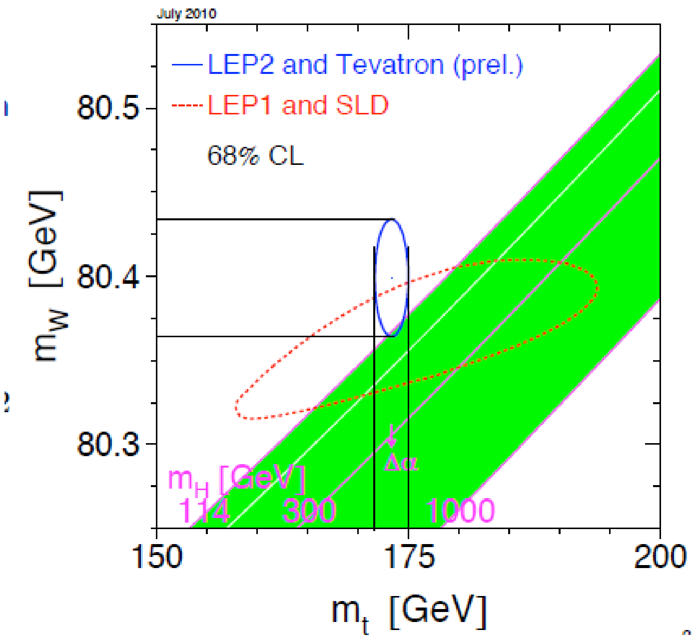


A = 0.33 ± 0.12 ± 0.01

- **Theoretical prediction for W charge asymmetry is to be ~0.2 with η–dependence**

Top physics

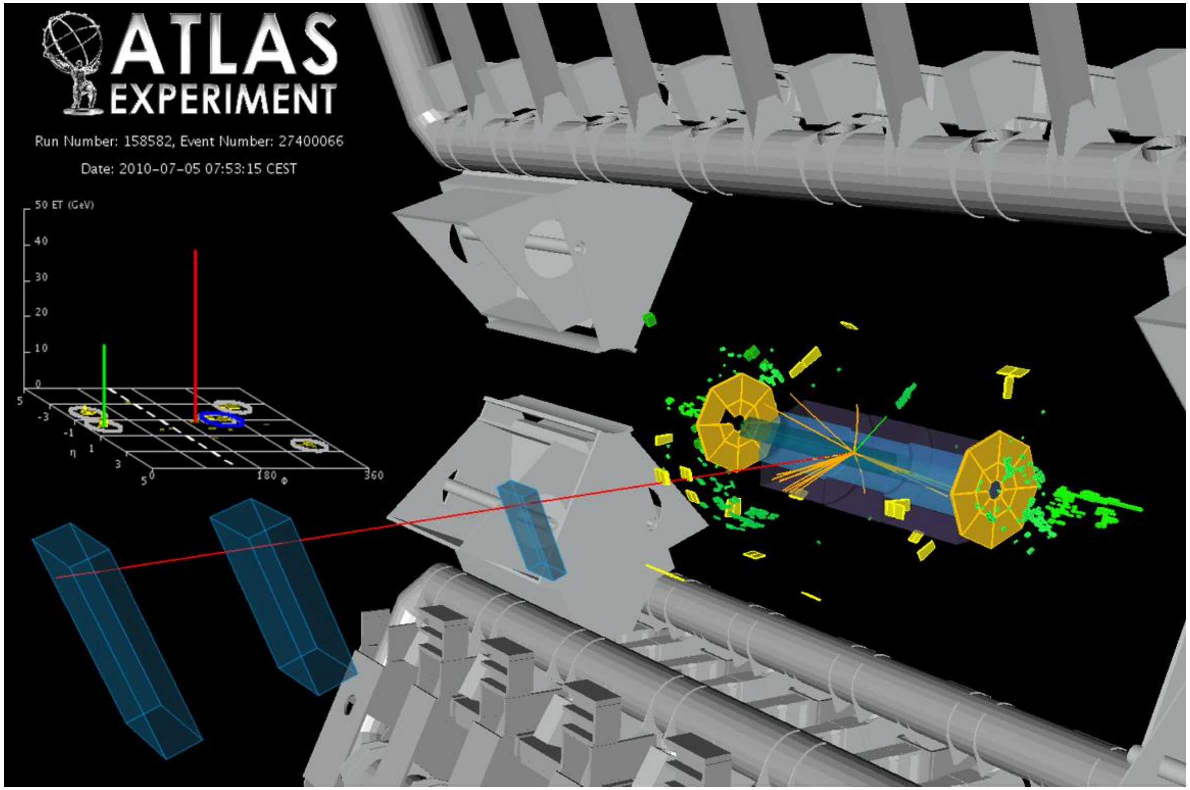
- ATLAS expects one top quark pair:
  - l+jet channel each 20 nb^{-1}
  - ll channel each 110 nb^{-1}
- For 1 fb^{-1} we can expect ~10 000 tops after selections
- Cross-section measurement (known with 6% uncertainty).
- Precise measurement of the top quark mass.
- Top-quark gives a unique opportunity to measure quark spin properties.
- Tevatron demonstrate 5σ-evidence of single-top. Precise measurements will only be possible at the LHC.



Present World Averages:

- M_W: 80.399 ± 0.023 GeV
- M_t: 173.3 ± 1.1 GeV

Top quark production

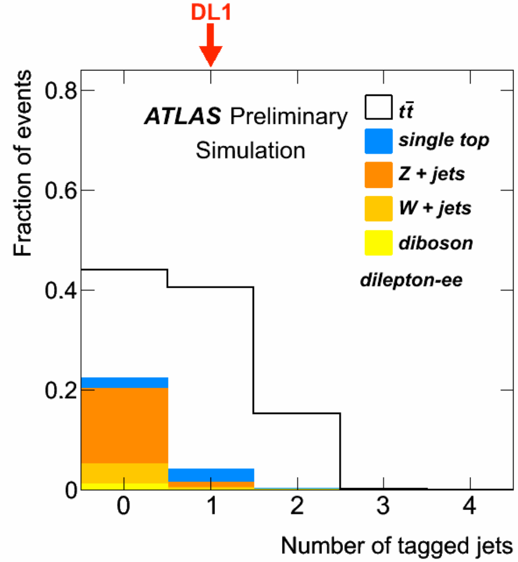


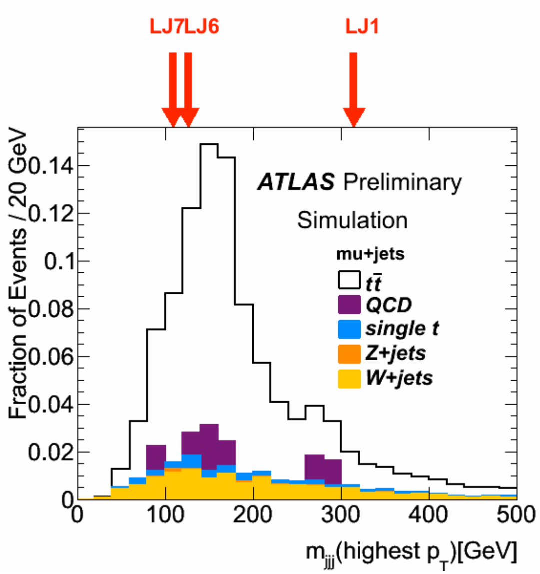
9 candidates (2 in di-lepton(**DL**) channel and 7 in semileptonic (**L J**))observed in all channels for 280 nb^{-1}

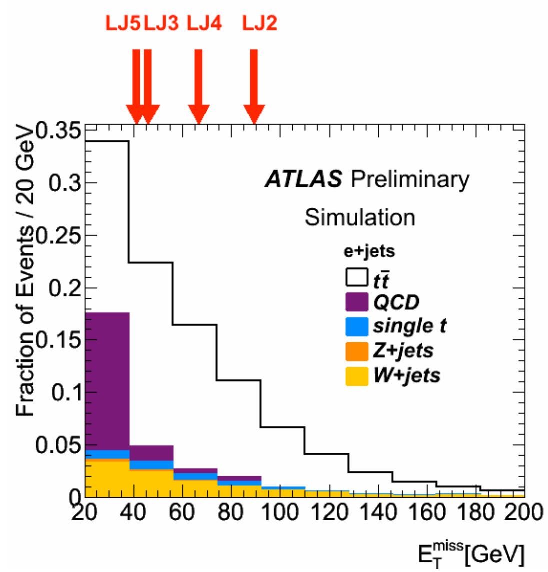
Top pairs

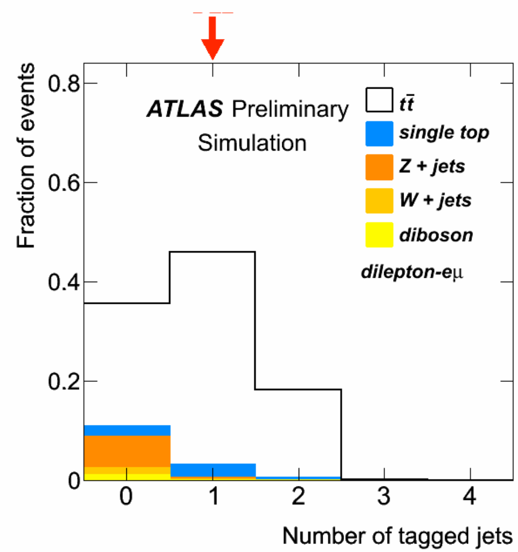
ID	Run number	Event number	Channel	p_T^{lep} (GeV)	E_T^{miss} (GeV)	H_T (GeV)	#jets $p_T > 20$ GeV	#b-tagged jets
DL1	155678	13304729	ee	55.2/40.6	42.4	271	3	1
DL2	158582	27400066	$e\mu$	22.7/47.8	76.9	196	3	1

ID	Run number	Event number	Channel	p_T^{lep} (GeV)	E_T^{miss} (GeV)	m_T (GeV)	m_{jjj} (GeV)	#jets $p_T > 20$ GeV	#b-tagged jets
LJ1	158801	4645054	μ+jets	42.9	25.1	59.3	314	7	1
LJ2	158975	21437359	e+jets	41.4	89.3	68.7	106	4	1
LJ3	159086	12916278	e+jets	26.2	46.1	62.6	94	4	1
LJ4	159086	60469005	e+jets	39.1	66.7	102	231	4	1
LJ5	159086	64558586	e+jets	79.3	43.4	86.7	122	4	1
LJ6	159224	13396261	μ+jets	29.4	65.4	64.1	126	5	1
LJ7	159224	13560451	μ+jets	78.7	40.0	83.7	108	4	1





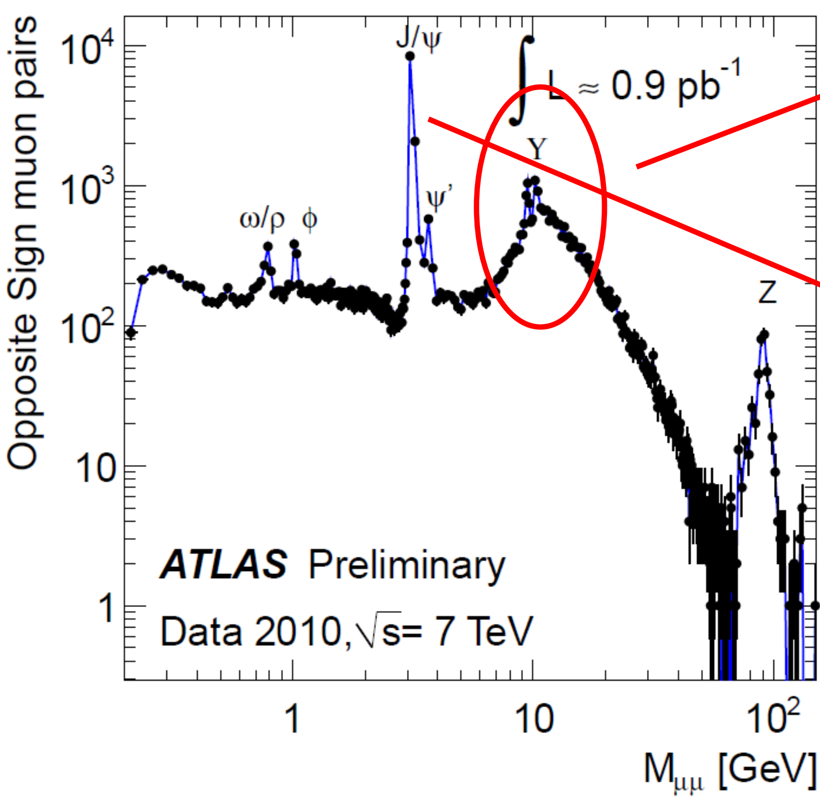


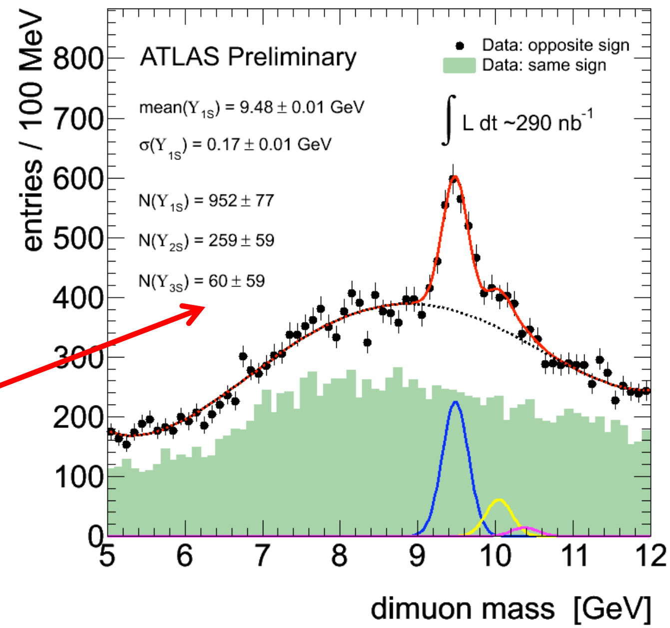


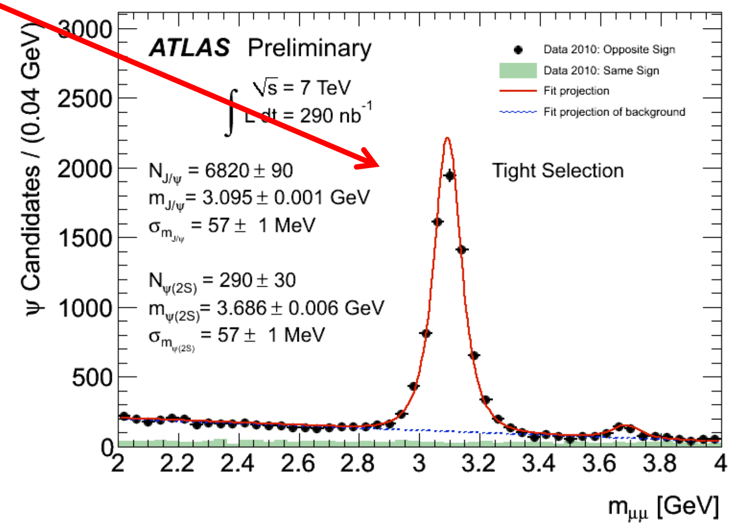
B-physics

- **10 pb-1: Measurement of production cross sections for B-hadrons and J/ψ,ϒ to test QCD predictions for pp collisions at the LHC**
- **100 pb-1:Studies of the properties of the complete B-meson family (B+, Bs, Bc, Λb + h.c.)**
- **1 fb-1: Precise measurements of weak B-hadron decays to search for BSM CP violating effects**

More details in K.Toms's report

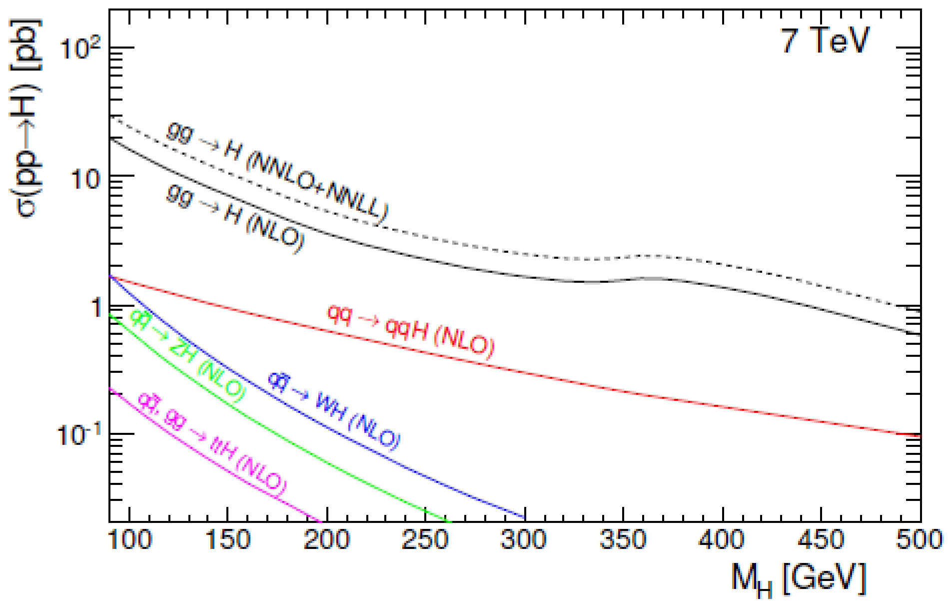






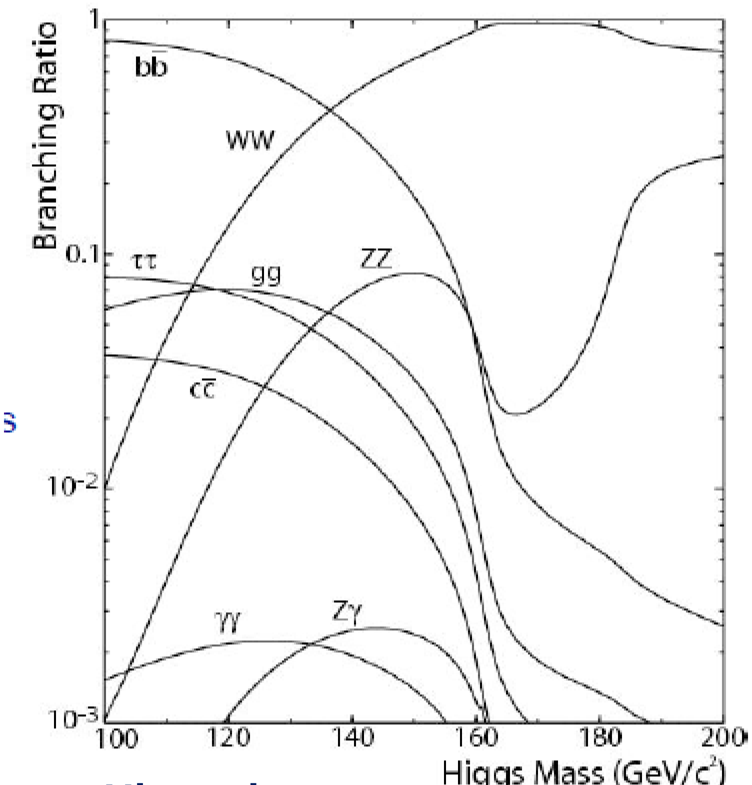
Higgs-Boson (SM)

ATL-PHYS-PUB-2010-009



Production cross-sections of the SM Higgs boson in *pp* collisions as functions of M_H for centre-of-mass energies of 7 TeV.

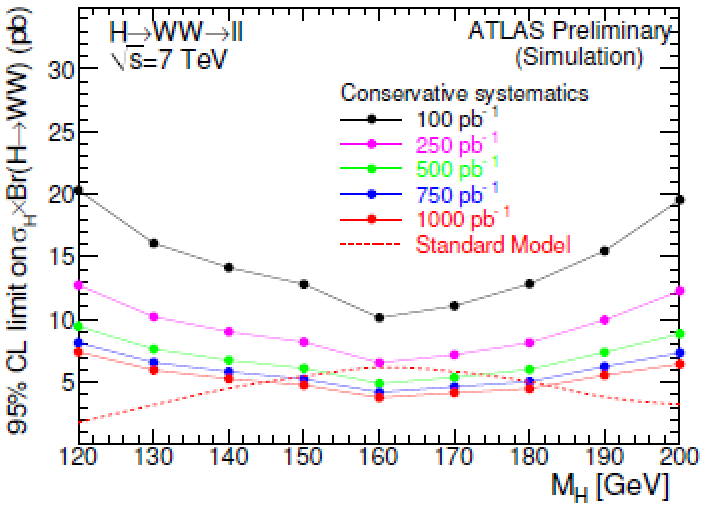
Presented results based on NLO calculation. Including NNLO will improve results.

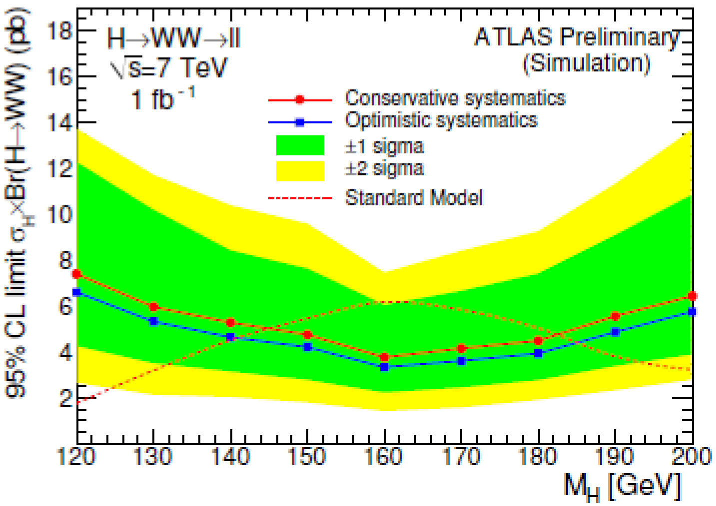


Higgs decays:
Doesn't depend on production mechanism
- **High mass: Dibosons**
- **Low mass: bb, gamma gamma, tau tau**

H→WW→lνlν

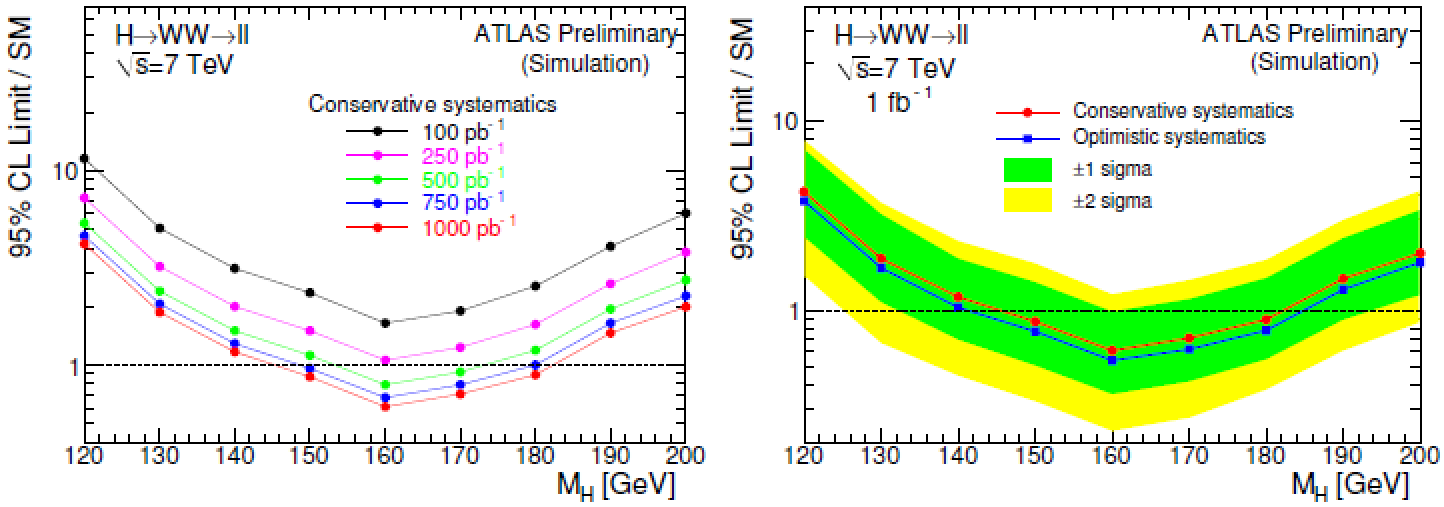
M_H (GeV)	120	130	140	150	160	170	180	190	200
SM WW	26.3	35.4	43.8	50.1	55.2	58.5	60.6	61.7	62.4
top	4.9	6.7	9.1	11.6	14.0	16.3	17.2	17.9	18.2
W+jets	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Total background	36.8	47.7	58.5	67.3	74.8	80.4	83.4	85.2	86.2
Signal	4.1	10.4	18.5	26.3	39.5	35.4	26.2	16.8	11.0





M_H (GeV)	120	130	140	150	160	170	180	190	200
SM $\sigma_H \times \mathscr{B}(H \to WW)$	1.76	3.18	4.50	5.45	6.17	5.83	5.03	3.80	3.23
Conservative systematics	7.4	5.9	5.3	4.7	3.8	4.1	4.5	5.5	6.4
Optimistic systematics	6.6	5.3	4.6	4.2	3.3	3.6	3.9	4.9	5.7

H→WW→lνlν



M_H (GeV)	130	140	150	160	170	180	190	200
Conservative Exclusion	12	1.6	0.68	0.28	0.41	0.76	2.7	4.5
Optimistic Exclusion	4.5	1.1	0.54	0.25	0.33	0.58	1.8	3.4
Conservative Discovery	95	18	16	4.8	6.6	17	68	96
Optimistic Discovery	36	8.1	5.5	2.3	3.1	6.7	31	52

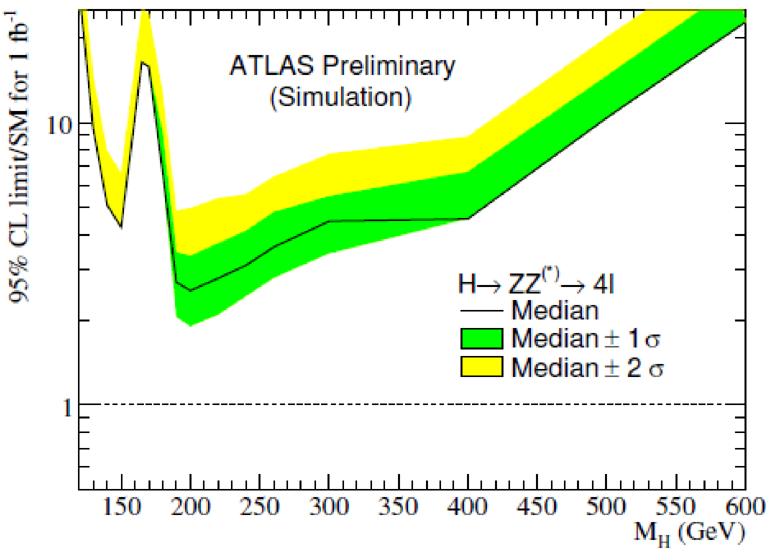
Minimum integrated luminosities in fb^{-1} required at $\sqrt{s}$ = *7* TeV for a 95%CL exclusion and 5σ discovery for the two systematic uncertainty assumptions in the H→*WW* channel.

H→ZZ→4l

M_H (GeV)	120	140	150	170	180	190	200	240	300	400	500	600
$\sigma_{NLO} \cdot \mathscr{B}$ [fb]	0.90	2.92	3.06	.65	1.43	4.41	4.82	3.82	2.68	1.85	0.79	0.35

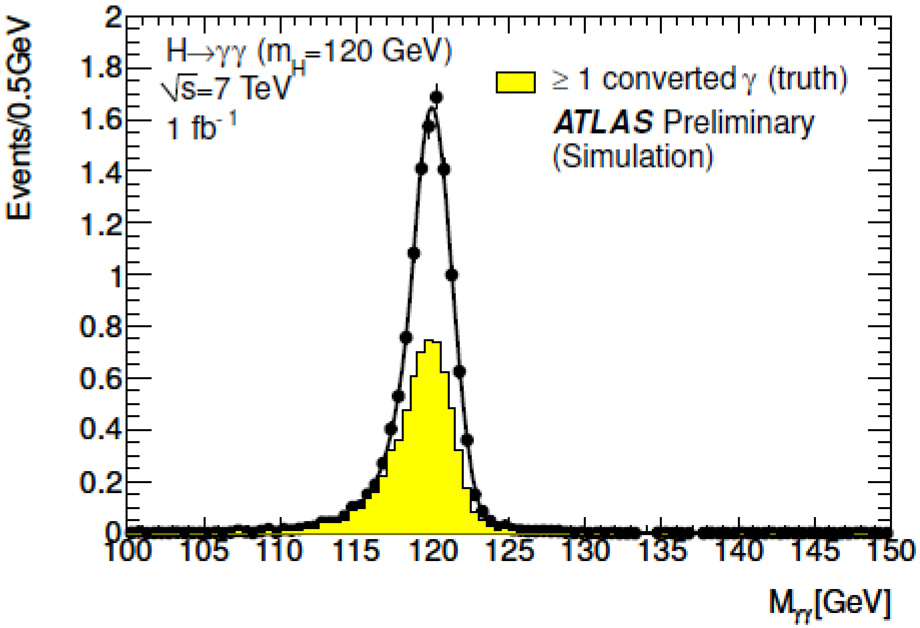
NLO Higgs to four lepton production cross-sections at √s = *7 TeV*, including the branching ratio *H →ZZ(*)* and the subsequent decay *Z →ll (l = e,μ)*.

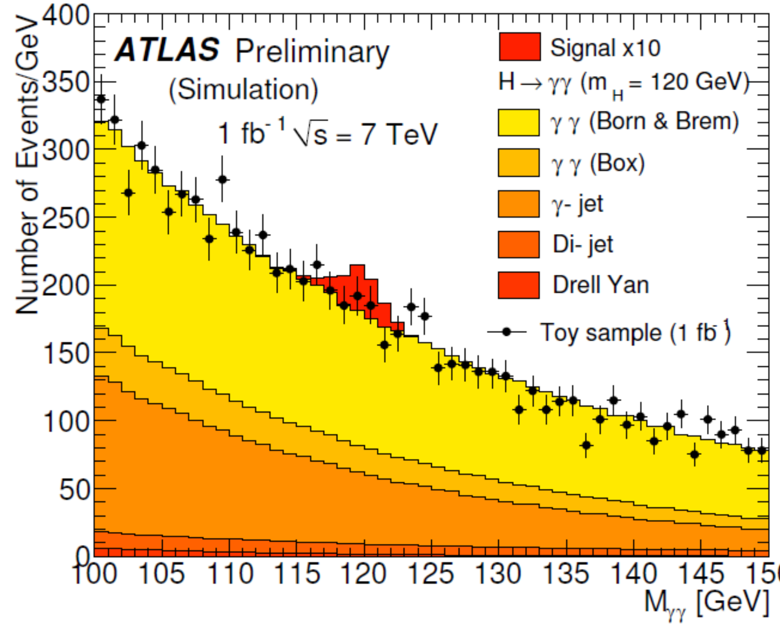
M_H(GeV)	120	130	140	150	165	170	180	190
SM ZZ	0.090	0.094	0.083	0.089	0.121	0.147	0.376	0.981
top & Z+jets	0.005	0.004	0.005	0.004	0.005	0.005	0.003	0.003
Total background	0.095	0.098	0.088	0.093	0.126	0.152	0.379	0.984
Signal	0.105	0.319	0.595	0.713	0.185	0.192	0.458	1.49
M_H(GeV)	200	220	240	260	300	400	500	600
SM ZZ	1.29	1.18	0.92	0.89	0.72	0.48	0.49	0.39
Signal	1.60	1.46	1.25	1.08	0.88	0.67	0.29	0.13



Estimated number of events in the signal region for the signal and the major backgrounds at an integrated luminosity of 1 fb^{-1} for √s = *7 TeV* after the full event selection in *H→ZZ →4l* (the 4e, 2e2μ and the 4μ final states are summed). SM ZZ background dominates above 200 GeV.

H→γγ

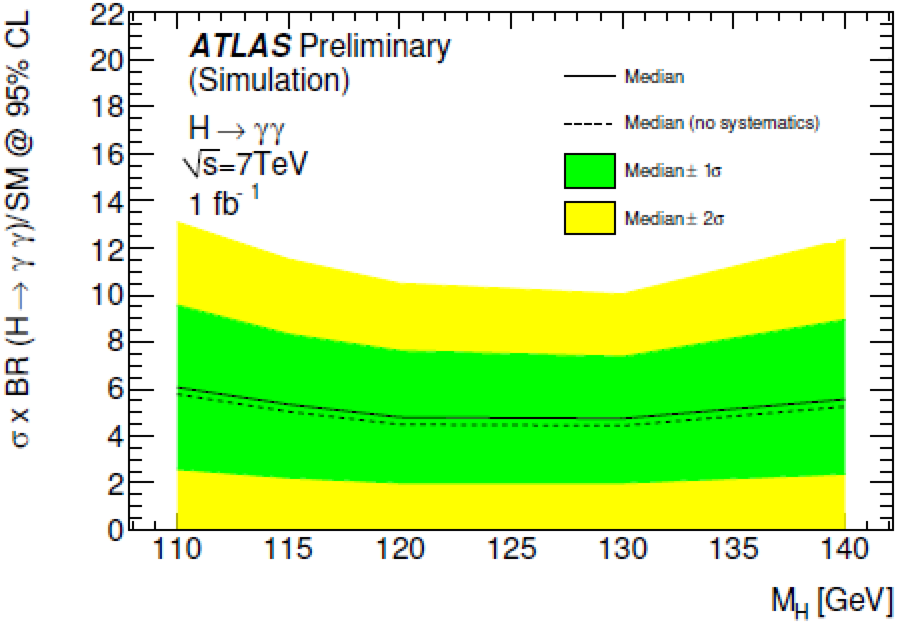


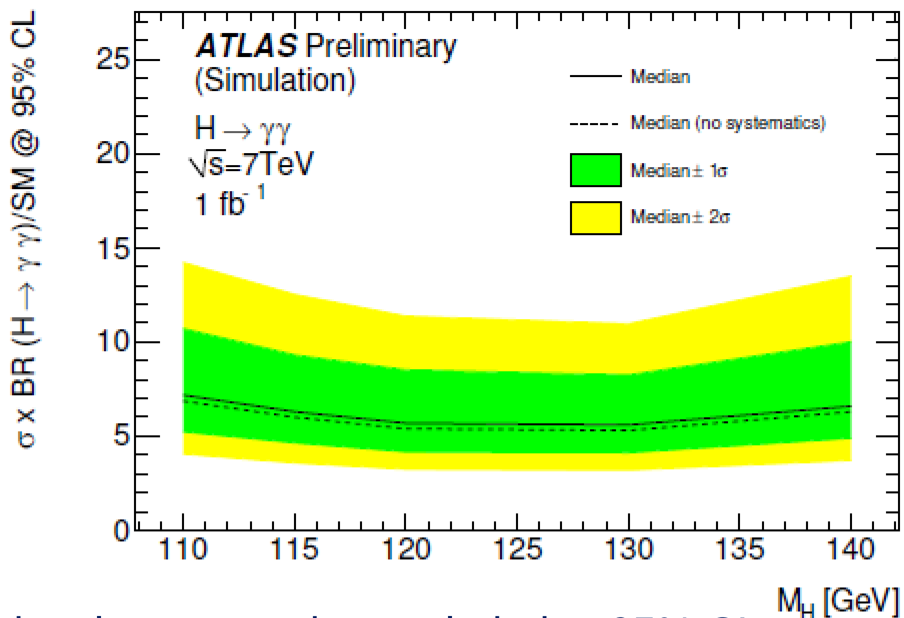


M_H (GeV)	110	115	120	130	140
$\gamma\gamma$	5540	5540	5540	5540	5540
γj	2500	2500	2500	2500	2500
jj	360	360	360	360	360
Drell Yan	90	90	90	90	90
Total background	8490	8490	8490	8490	8490
Signal	12.6	12.8	13.0	12.0	9.2

H→γγ

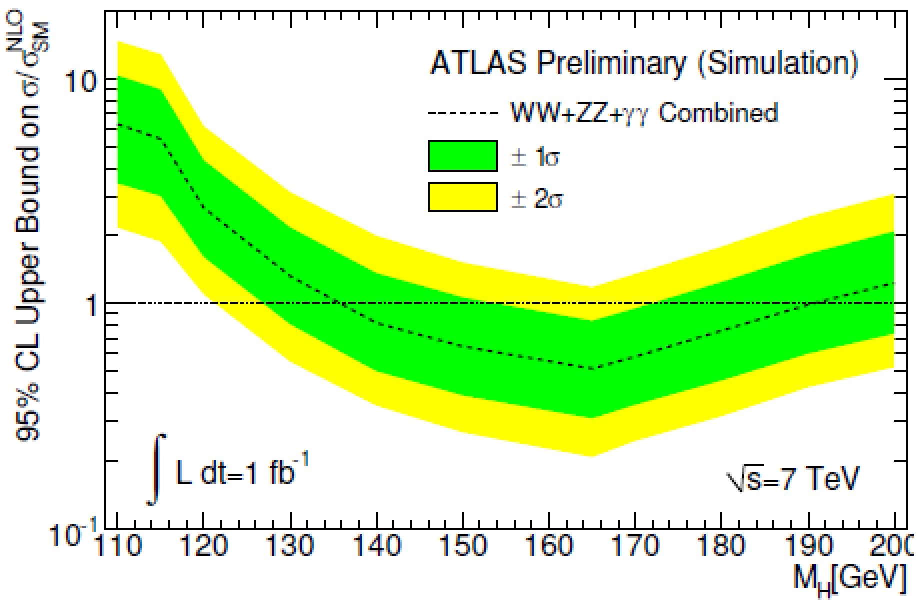
m_H (GeV)	110	115	120	130	140
Expected exclusion	5.8	5.0	4.6	4.4	5.2

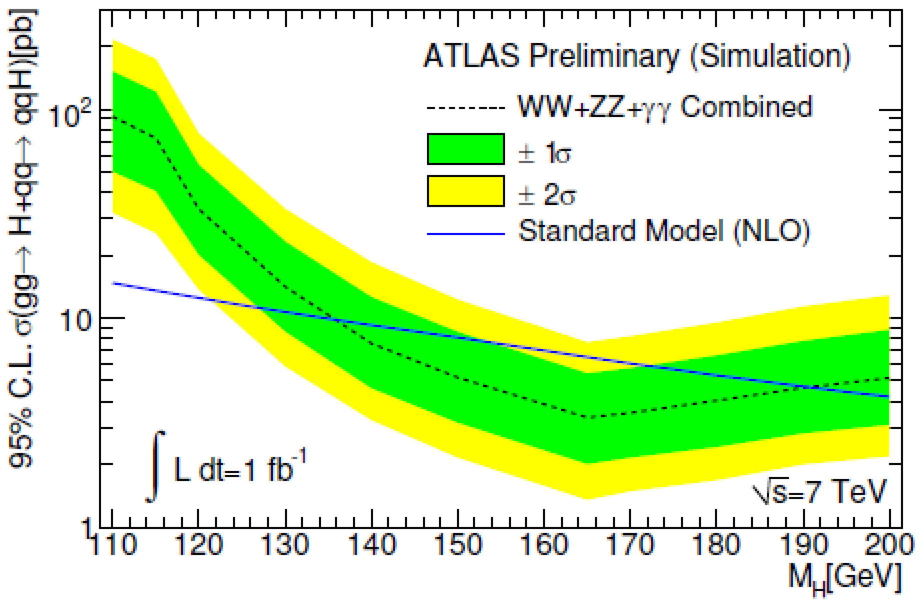




The estimated number of Standard Model signal cross-section excluded at 95% CL as a function of the Higgs mass for an integrated luminosity of 1 fb^{-1}. The Frequentist limit shown allows the observed upper limit to be zero (left plot). For comparison, on the right plot, we show the limit with the CLS method used at LEP and Tevatron experiments. The green and yellow bands represent the range in which we expect the limit will lie, depending upon the data.

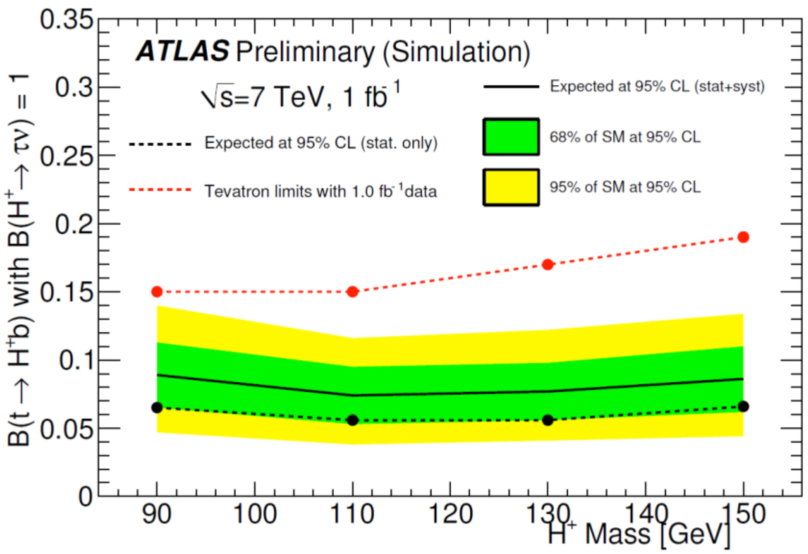
Combination of $H \to WW, ZZ, \gamma\gamma$

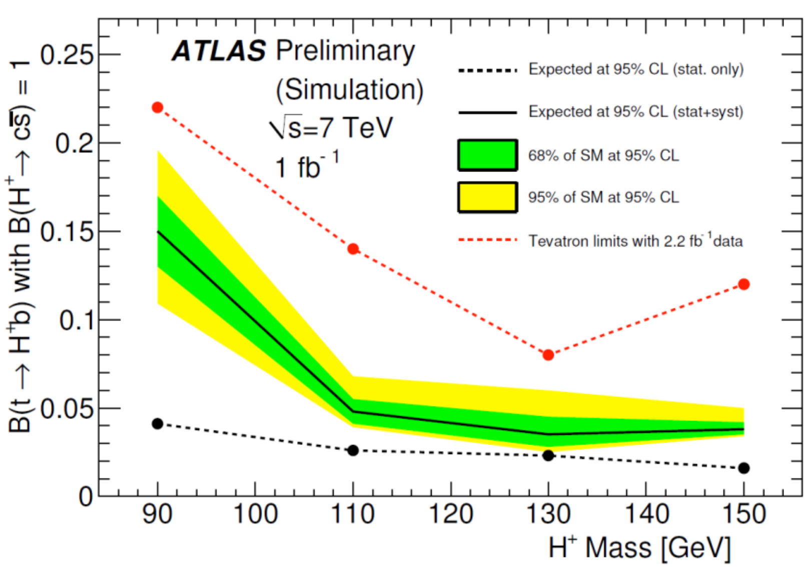




The expected upper bound on the Higgs boson production cross-section after collecting 1 fb-1 of integrated luminosity in 7 TeV collisions with the ATLAS detector: on the right plot, the limit is normalised to the NLO prediction of the SM cross-section and on the left plot, it is normalised to an absolute cross-section. The green and yellow bands represent the range in which we expect the limit will lie, depending upon the data. Only the *H→WW→llnn* , *H→ZZ→4l* and $H \to \gamma\gamma$ channels are included in these plots. It is expected that in the low mass region, the addition of *H→bbbar and* $H \to \tau\tau$ will improve this result. The expected limit in high mass region above M_H *~200 GeV* is obtained from the H→ZZ→4l only as shown on p.16 the limit in the high mass region will be improved with the addition of the H→ZZ→llbb and H→ZZ→llνν channels.

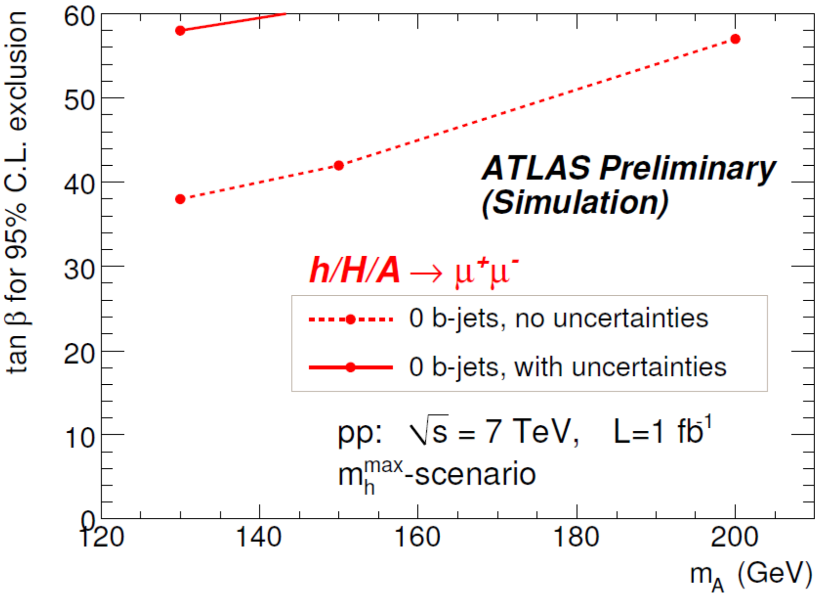
BSM: Charged Higgs (t→H$^\pm$→τν/csbar)

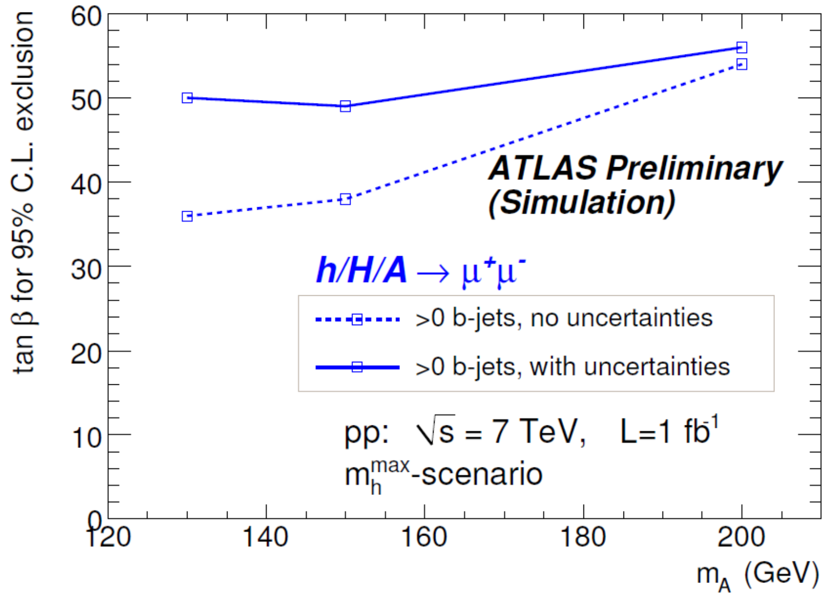




- Possible in case M_H<M_t
- In case tanβ>1 H$^\pm$→τν dominates (left plot)
- H$^\pm$→csbar dominates in case tanβ<1(right)

MSSM Higgs boson





The tanβ values needed for an exclusion of the neutral MSSM Higgs bosons shown as a function of the Higgs boson mass m_A, separately for the (left) analysis mode with 0 b-jet and (right) analysis mode with at least one *b*-jet. An integrated luminosity of $1\ fb^{-1}$ and $\sqrt{s} = 7\ TeV$ are assumed. Dashed lines represent the results assuming zero uncertainty on the signal and background, while the full lines correspond to the results with both signal and background uncertainty taken into account.

expected ATLAS reach for exotics

W' (SSM): Tevatron limit ~ 1 TeV (95% C.L)

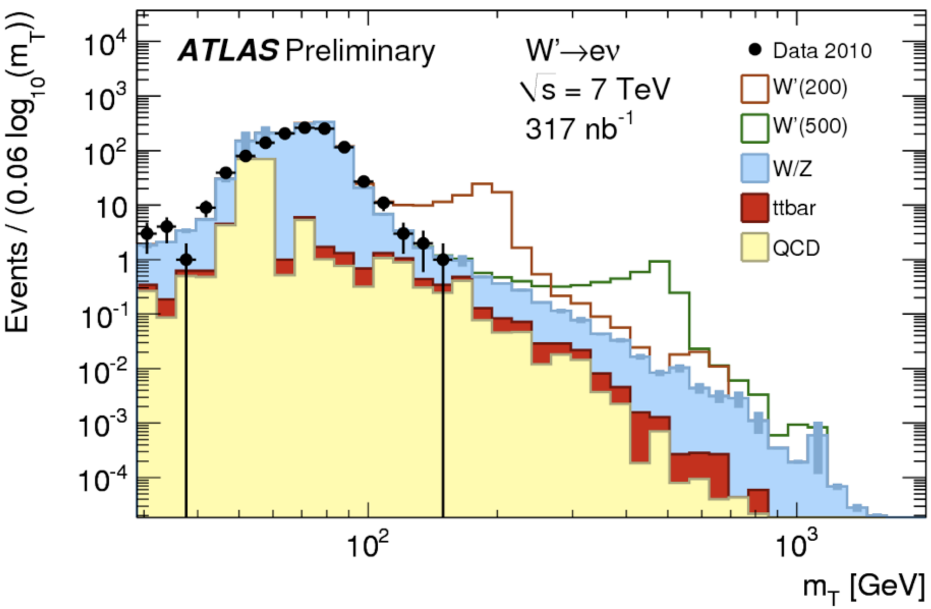
- 10 pb-1 : exclusion ~ 1 TeV
- 20 pb-1 : discovery ~ 1 TeV
- 50 pb-1 : exclusion ~ 1.5 TeV
- 100 pb-1 : discovery ~ 1.5 TeV
- 1 fb-1 : discovery ~ 2 TeV

Z' (SSM): Tevatron limit ~ 1 TeV (95% C.L)

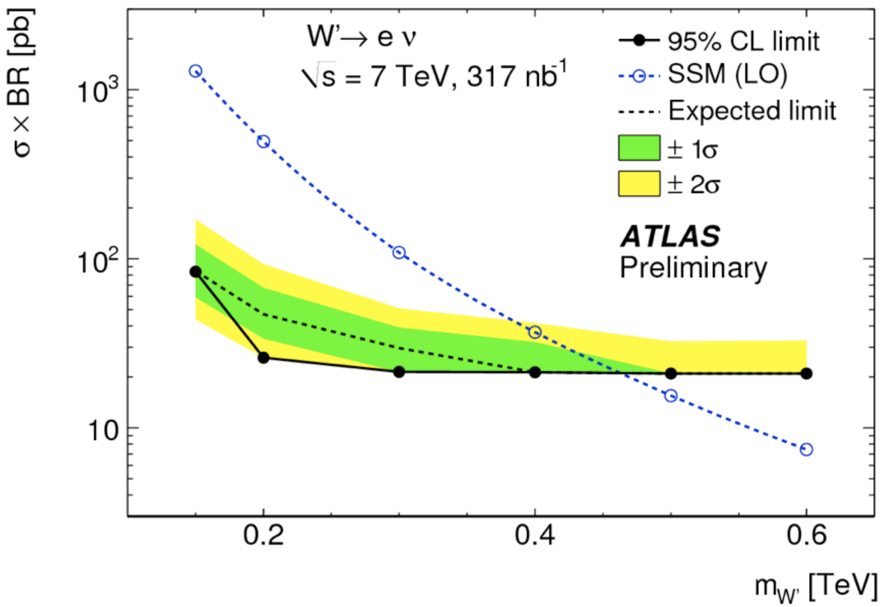
- 50 pb-1 : exclusion ~ 1 TeV (95% C.L.)
- 100 pb-1 : discovery ~ 1 TeV
- 300 pb-1 : exclusion ~ 1.5 TeV
- 1 fb-1 : discovery ~ 1.5 TeV

Exotics: W' search

Transverse mass spectra after the final selection

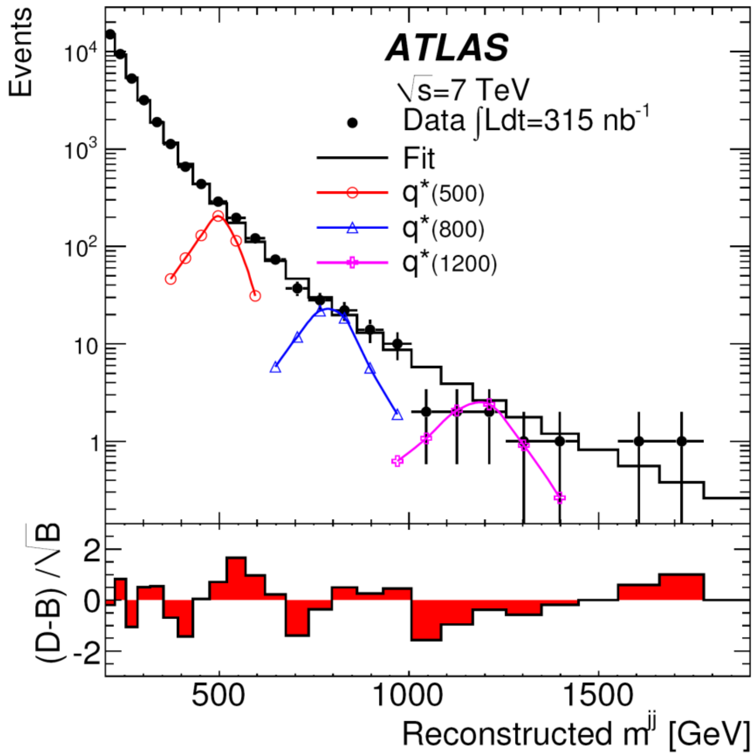


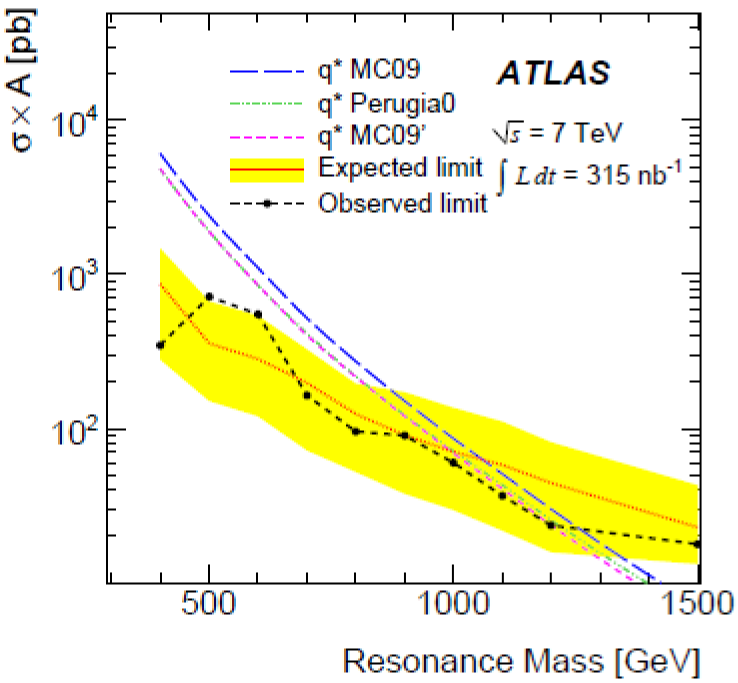
Limits on W' production and Pythia SSM predictions



Observations are consistent with the limits observed at the Tevatron. Approximately 5 pb^{-1} will be needed to begin to extend those limits for both electron and muon channels combined and we have over 3 pb^{-1} for the moment.

Exotics: di-jets search





95 % C.L. limits on q*:

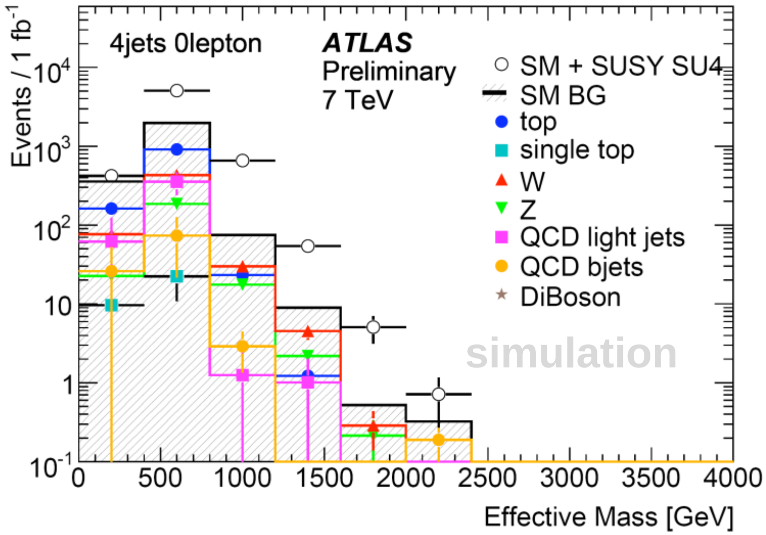
400 < mq∗ < 1290 GeV (with MRST2007)

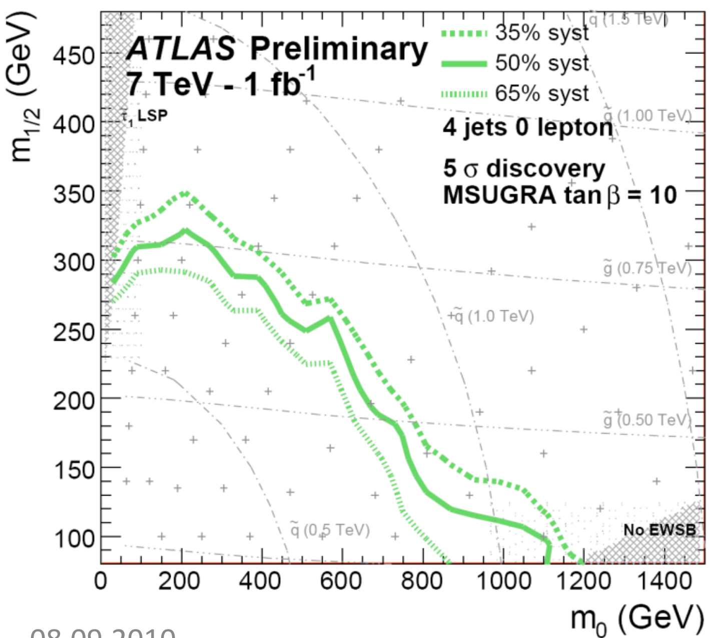
cf. CDF Collaboration, Phys. Rev. D 79 (2009) 112002:

260 < mq∗ < 870 GeV

ATLAS already starts to extend Tevatron limits

SUSY





Benchmark SUSY scenario:

- **"SU4" σ ~ 60 pb**
- **m0=200 GeV, m1/2=160 GeV, A0=-400 GeV,**
- **tanβ=10 and μ>0**
- **Low mass point above Tevatron limits:**
- **m(squarks, gluinos) ~410-420 GeV**
- **current best limits from Tevatron:**
- **m(squark) > 280 GeV**
- **m(gluino)> 340 GeV**

ETmiss + 4 jets + 0 lept"

- **best discovery potential**
- **dominant backgrounds:**
  - **Top production (pair, single)**
  - **Vector Bosons + jets**

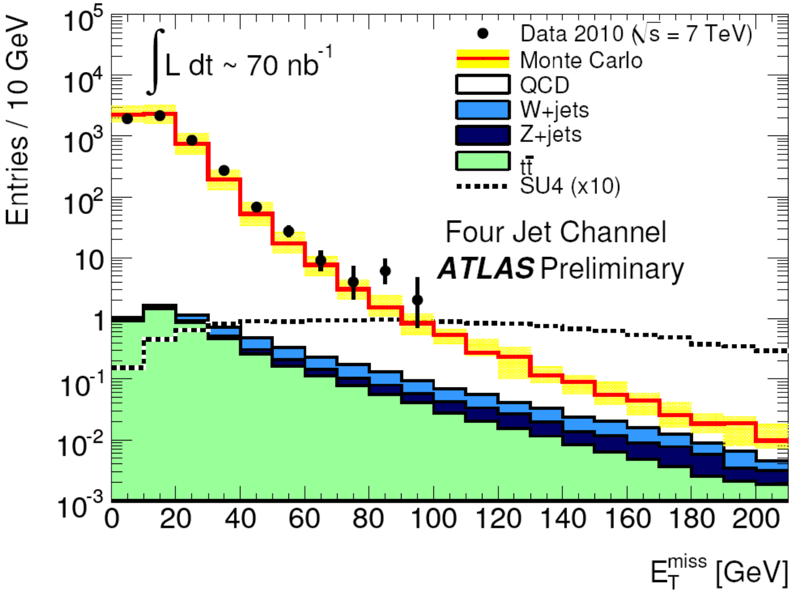
Discovery potential in mSUGRA plane

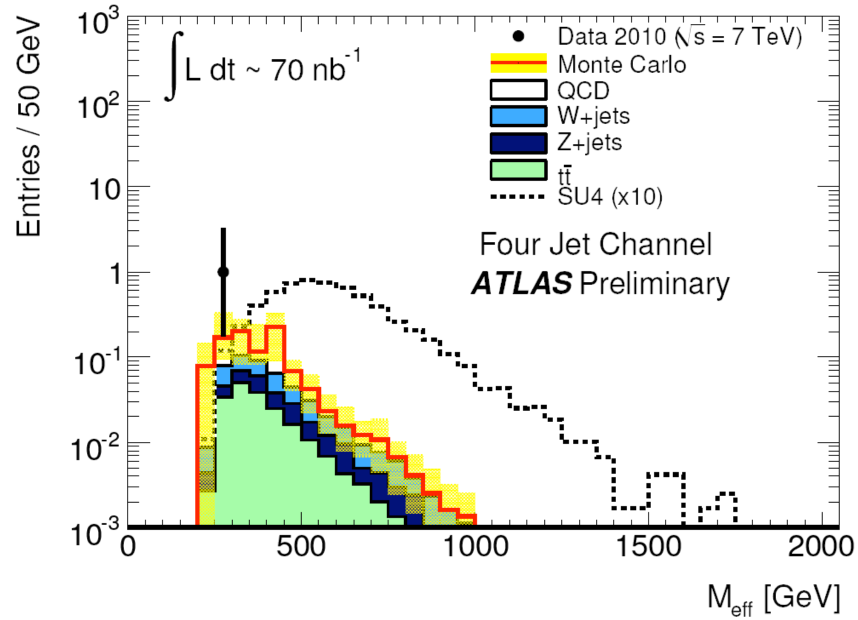
- **∫Ldt=1fb-1**
- **optimized Meff cut at each point**
- **Expected uncertainty from data ~50 %**

>=4 Jets +ETmiss channel

Preselection: (70nb^{-1})
• ≥4 jets with pT>70 (30) GeV

Final selection:
• ET,miss>40GeV, ΔΦ(ji, ET,miss)>0.2
• ET,miss/Meff> 0.3-0.2





- Preselection: QCD shape well-described described by MC
- Final selection: 1 event in data; expected: 1.0±0.6
- ATLAS will extend Tevatron limits with 10 nb^{-1}

conclusion

- ATLAS steps up to the new era of searches at $\sqrt{s}$=7 TeV
- Many SM results (see ***ATLAS results on QCD and quarkonia production*** , K. Toms and ***ATLAS EW results***, G.Salamanna talks on this conference)
- ATLAS will start to exclude SM Higgs in range 135 GeV-190 GeV with 1 fb^{-1}.
- Important benchmark searches like W',Z', Supersymmetry, etc. are underway
  - Searches use jets, ETmiss, leptons, photons, btagging, etc.
  - Preliminary results show that data are consistent with SM background predictions

These searches will soon be sensitive to New Physics beyond current limits