Highlights from the ATLAS Experiment

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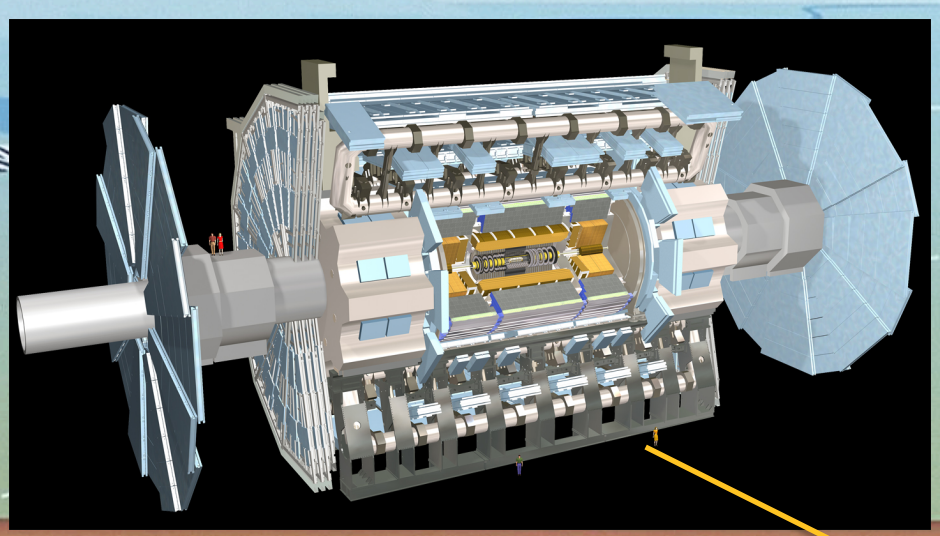
on behalf of the ATLAS Collaboration

The ATLAS Experiment at the CERN Large Hadron Collider



This talk reflects the work of 3000 people from 38 countries.

All of the topics presented here have been announced for the first time in 2012. They are based on data collected in 2010-2011.
These 24 results are a sample of the 60 papers submitted for publication thus far this year.

Please do not miss the other ATLAS talks by

Evangelos Gazis: Detector performance
Lucio Cerrito: Top
Stephanie Adomeit: QCD
Nick Charles Edward: W, Z, and diboson physics
Visili Mitsou: SUSY
Serhan Mete: New physics searches
Steve Hillier: Upgrade
Zvi Citron: Heavy Ions
Kirill Prokofiev: Higgs

Exotics

$W_R{}'$

Micro black holes and string balls

$b' \to Zb,\ b' \to Wt,\ t' \to Wb$

Heavy neutrinos

Second generation scalar leptoquarks

Randall-Sundrum graviton

New bosons

Contact interactions

Excited leptons

Higgs

Fermiophobic

$H \to \gamma\gamma$

$H^+ \to \tau\upsilon$

$H \to ZZ^{(*)} \to 4\ell$

H^{++}

Top

Charge asymmetry in pair production

FCNC single top

Standard Model

Strange quark density of the proton

Inclusive two-particle angular correlations

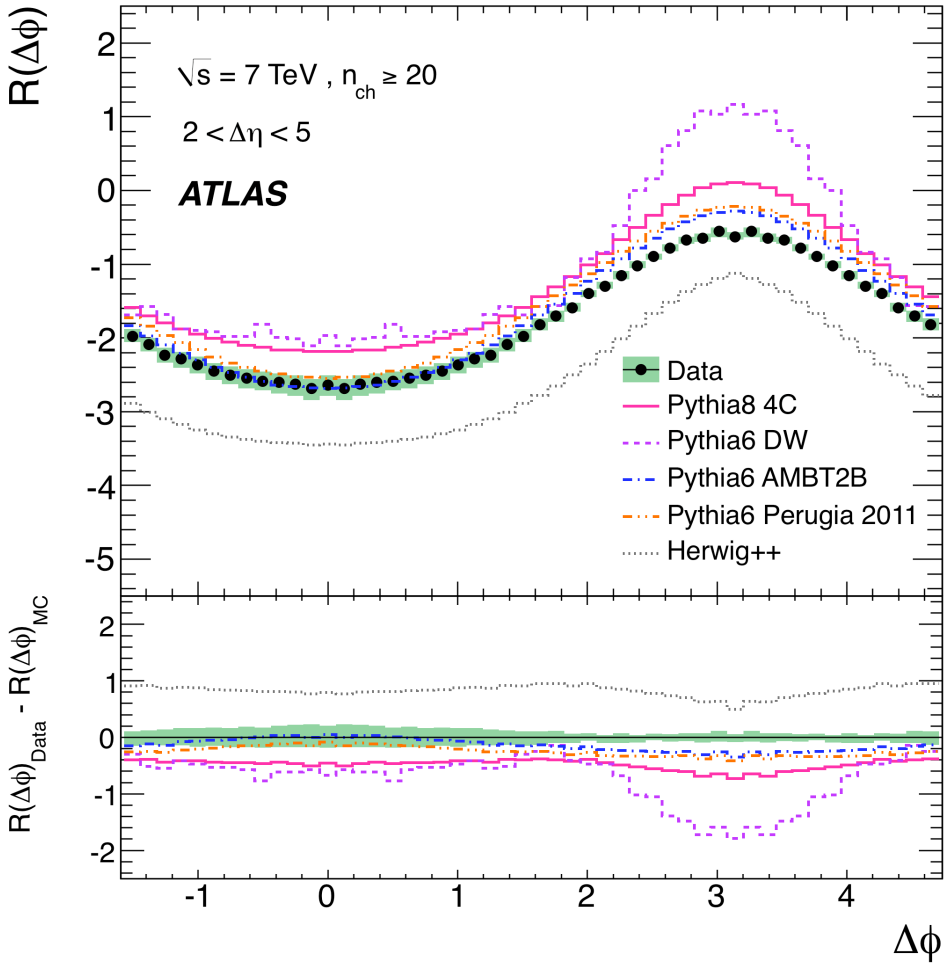
Isolated photon + jets

Azimuthal ordering of charged hadrons

Measurement of inclusive two-particle angular correlations

The sample: minimum bias charged particles with $p_T > 100$ MeV and $|\eta| < 2.5$. Measurements at $\sqrt{s} = 900$ GeV and 7 TeV are compared to predictions by PYTHIA 8, HERWIG++, and 3 tunes of PYTHIA 6.

No model satisfactorily describes the data. This impacts the phenomenology of soft particle production including models for diffraction and hadronization but may go beyond retuning existing models.



arXiv:1203.3549v1[hep-ex]

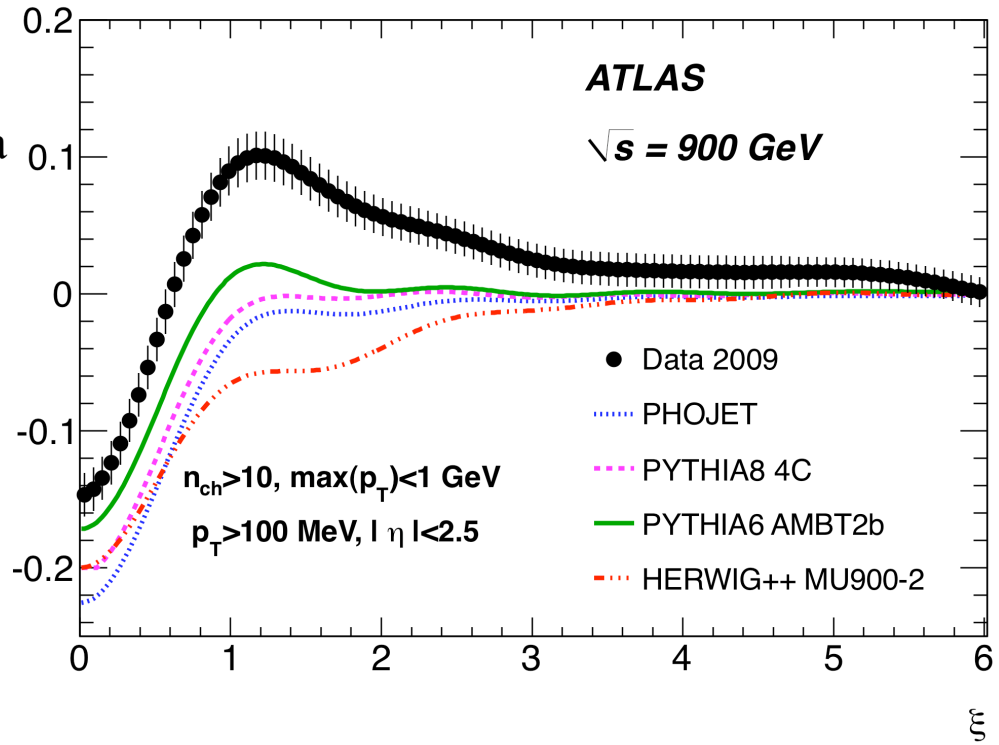
Measurement of the azimuthal ordering of charged hadrons

Tests models of QCD at low energy scales, typically in combination with non-perturbative effects. The measurements are sensitive to the definition of the phase space.

Predictions based on the Lund model roughly reproduce inclusive power spectra in $\sqrt{s}$ = 900 GeV and 7 TeV. Models systematically overestimate correlations, especially in phase space regions dominated by diffractive events.

Inclusion of azimuthally ordered fragmentation (helically ordered gluon chains) may improve models of fragmentation and soft production.

Here: Power spectrum versus azimuthal opening angle (helix phase difference). No model adequately describes the samples with enhanced low-p_T components.



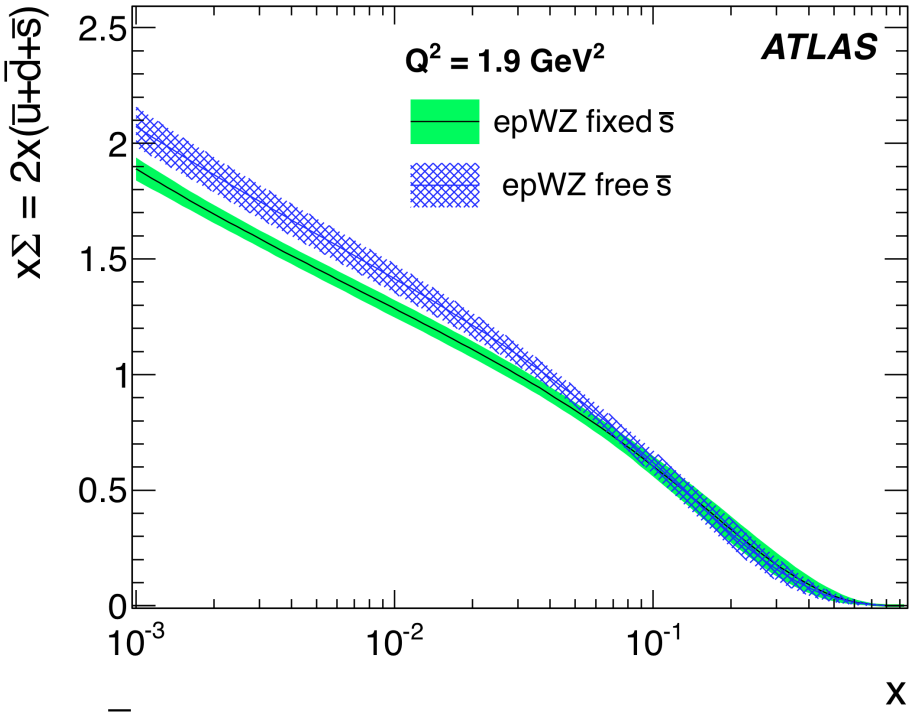
arXiv:1203.0419v1[hep-ex]

Determination of the strange quark density of the proton

Differential measurement of $W \to \ell\nu$ and $Z \to \ell\ell$ cross sections points to a flavor-symmetric light quark sea at low x.

New constraints on the strange quark distribution at scale $Q^2 \sim M_Z^2$, and at low Q^2 by pQCD evolution, when combined with HERA *ep* results.

New sensitivity to the *s* quark density at $x \sim 0.01$. $r_s = 1.00^{+0.25}_{-0.28}$ at $x_{Bj} = 0.023$ and $Q^2 = 1.9$ GeV^2.

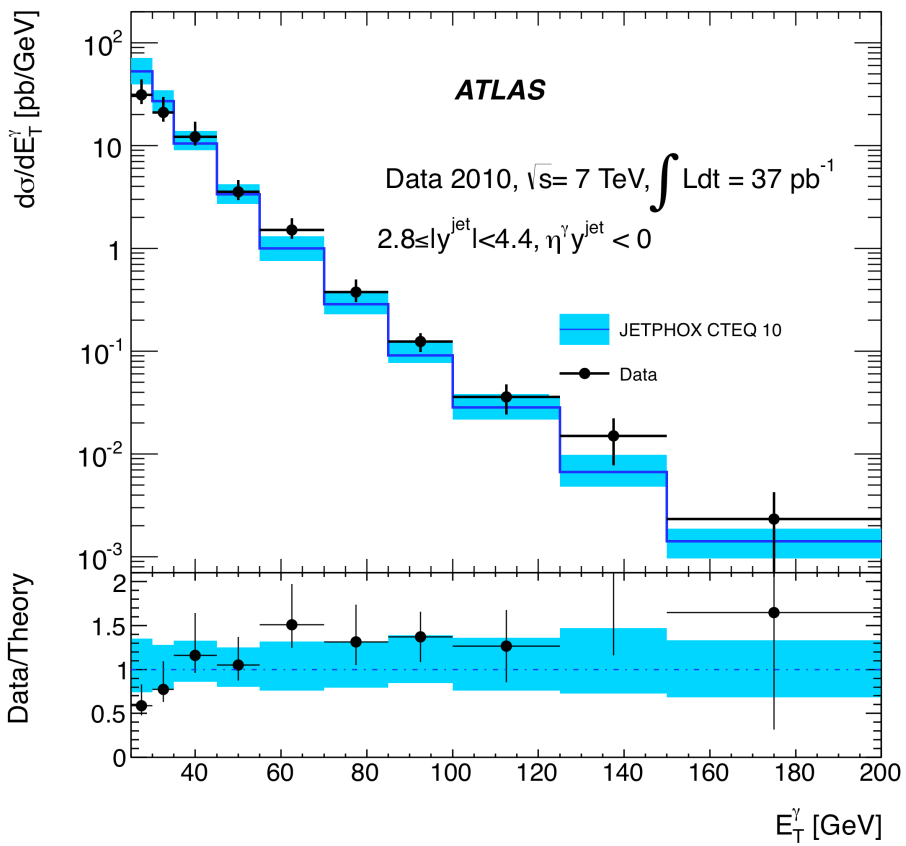


Here: The total sea $x\Sigma = 2x(\bar{u} + \bar{d} + \bar{s})$ is enhanced by about 8% compared to the scenario with *s* suppressed to half the magnitude of *u* and *d*.

arXiv:1203.4051[hep-ex]

Production cross section of an isolated photon with jets

- Prompt photon production tests pQCD at large hard-scattering scales and over a wide range of parton momentum fraction x.
- Photon-jet angular correlations constrain the photon fragmentation functions and (through $qg \rightarrow q\gamma$) the gluon density function.
- γ+jet is main bkg to $H \rightarrow \gamma\gamma$
- JETPHOX agrees well with data except in region $E_t^{\gamma} < 45$ GeV.



Here: example γ-jet production cross sections for very forward jet, with photon and leading jet pseudorapidity of opposite sign.

arXiv:1203.3161v1[hep-ex]

Measurement of the charge asymmetry in top quark pair production

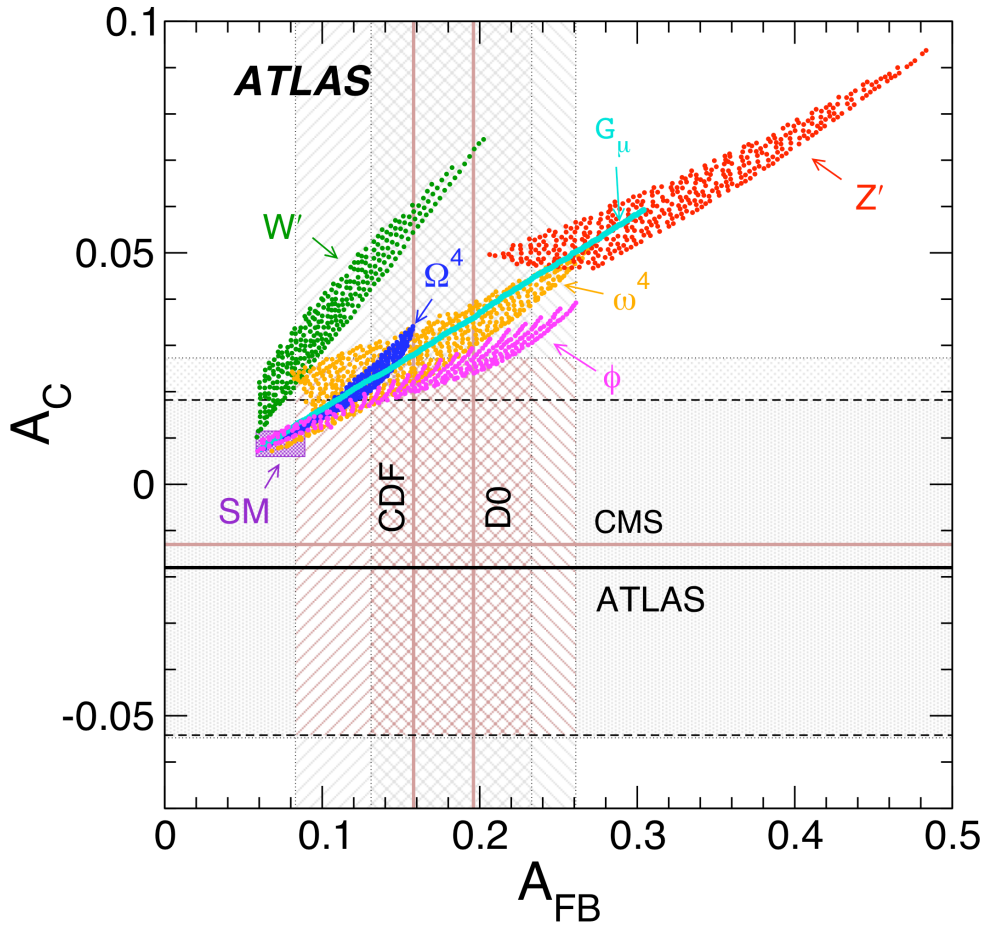
$$A_C = \frac{N(\Delta|y| > 0) - N(\Delta|y| < 0)}{N(\Delta|y| > 0) + N(\Delta|y| < 0)}$$

where $\Delta|y| \equiv |y_t| - |y_{\bar{t}}|$

Data set: events with a single lepton, missing p_T, a *b*-jet, and at least 3 more jets.

Measurement $A_C = -0.018 \pm 0.028 \pm 0.002$ is consistent with prediction from MC@NLO of 0.006 ± 0.002.

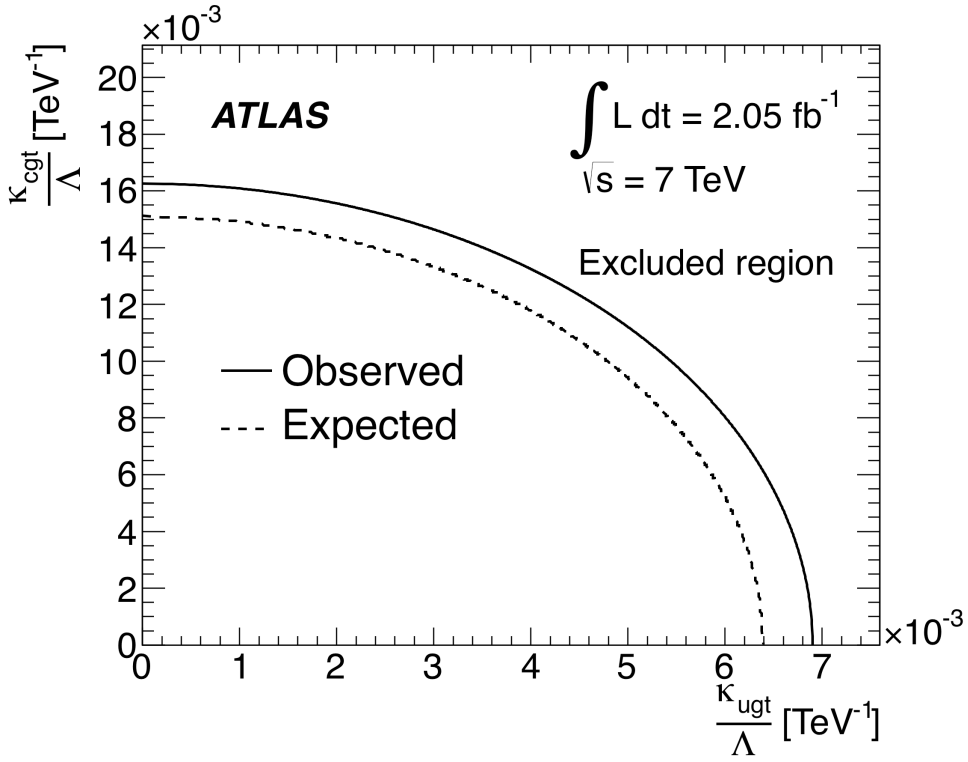
LHC measurements are in tension with Tevatron measurements and new models assuming a W' or Z'.

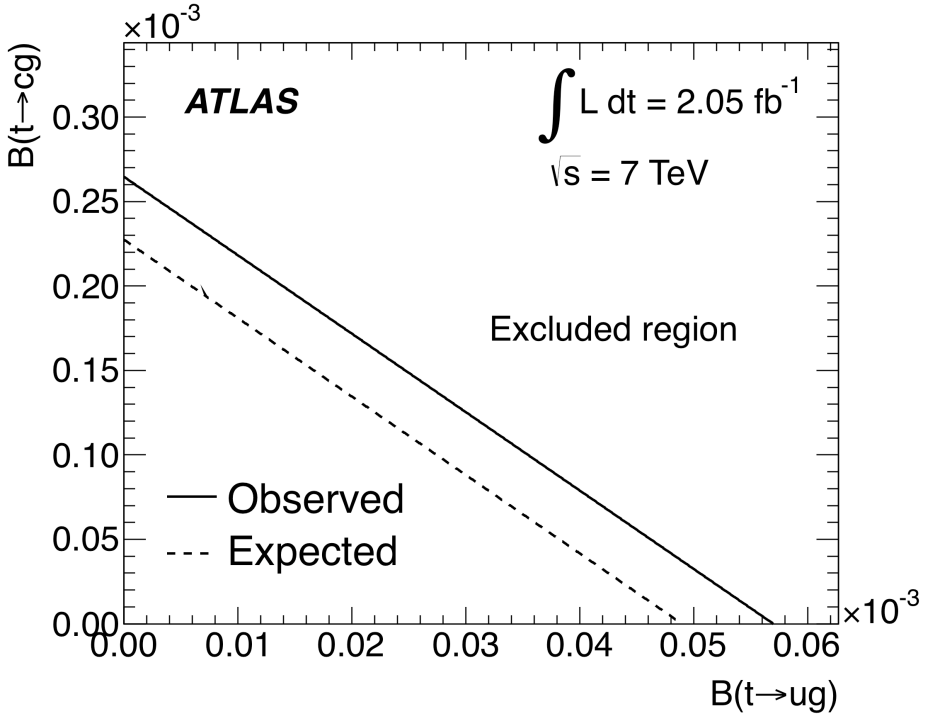


arXiv:1203.4211v1[hep-ex]

Search for flavor changing neutral current single top quark production

Suppressed in the Standard Model by GIM mechanism; observation would signal new physics.
A neural network is applied to semileptonic top decays.

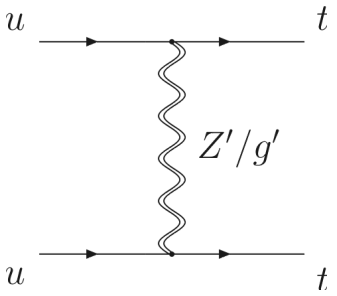




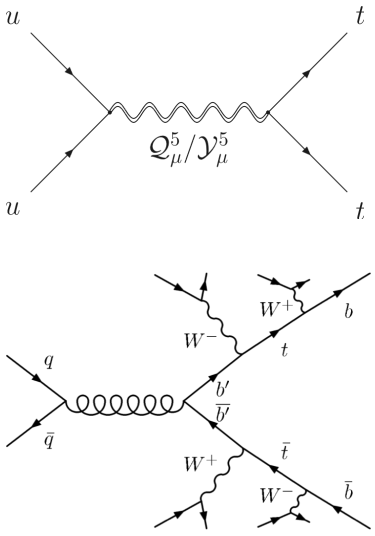
Here: ATLAS limits on BR and coupling are the most stringent to date on qg→t.

arXiv:1203.0529v1[hep-ex]

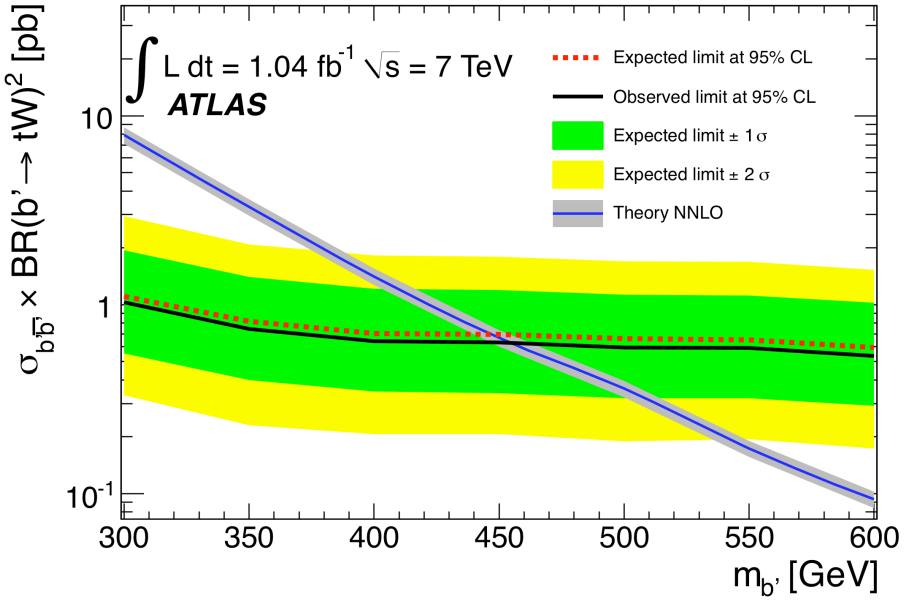
Search for same-sign top quark production and fourth generation down-type quarks



Data set: final states with 2 isolated same-sign leptons, ≥ 2 jets, and large E_T^{miss}. Result: 95% CL limits of 1.7 pb are set on the x-section for each chirality of BSM mediators: charge-4/3 color triplet Q_μ^5, color sextet y_μ^5, charge-neutral color singlet Z', color octet g'.



Here: lower bound 450 GeV on $m_{b'}$



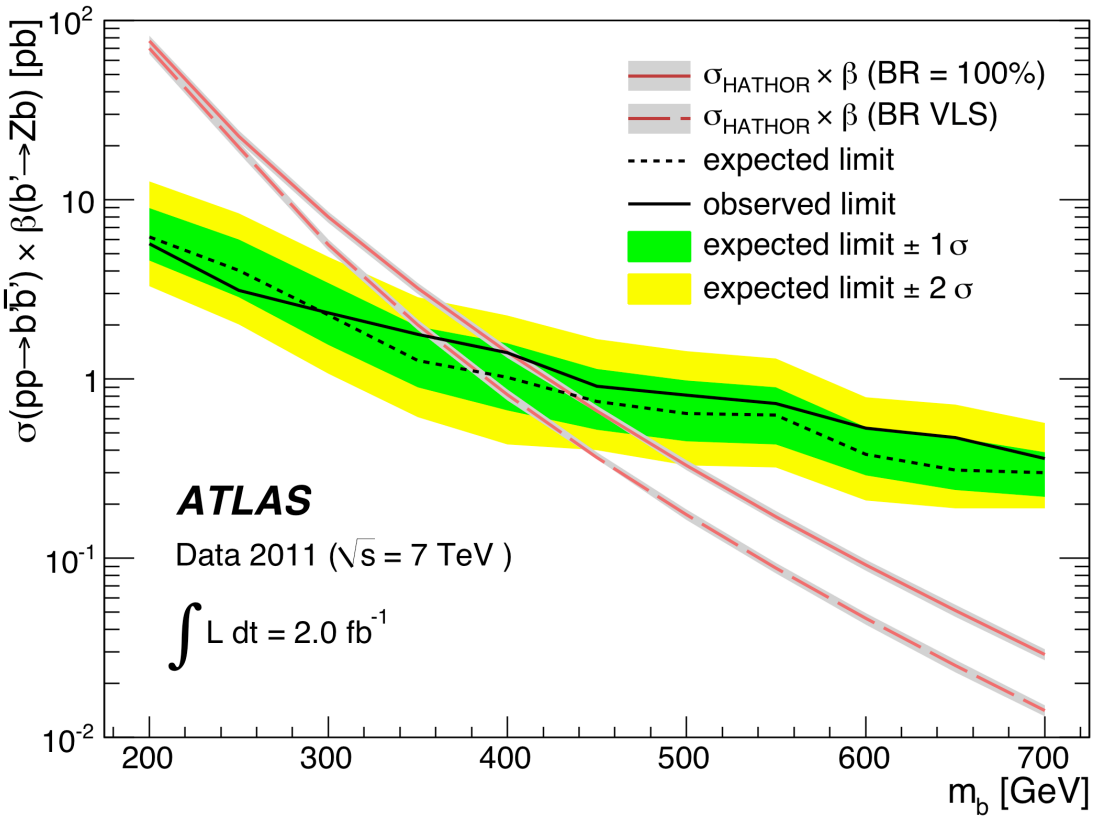
arXiv:1202.5520v2[hep-ex]

This is the strongest limit in the like-sign channel.

Search for $b' \rightarrow Z + b$

Sample: Events with a *b*-tagged jet and a $Z \rightarrow e^+e^-$.

Pair production search excludes masses $m_{b'} < 400$ GeV, a significant improvement over the previous limit of 268 GeV.

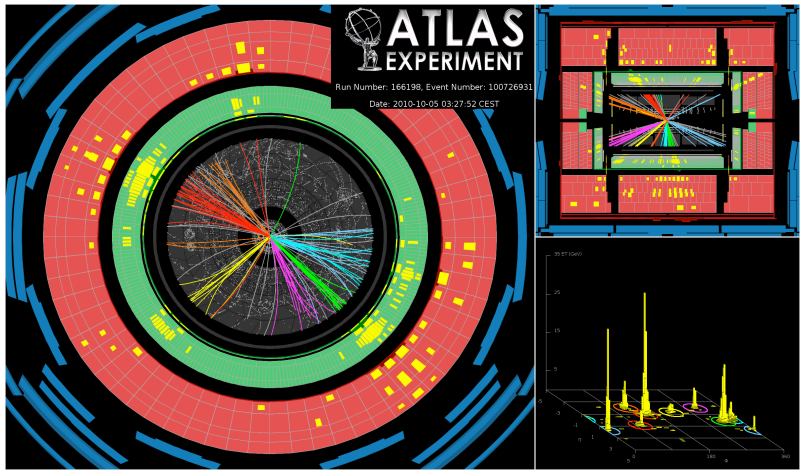


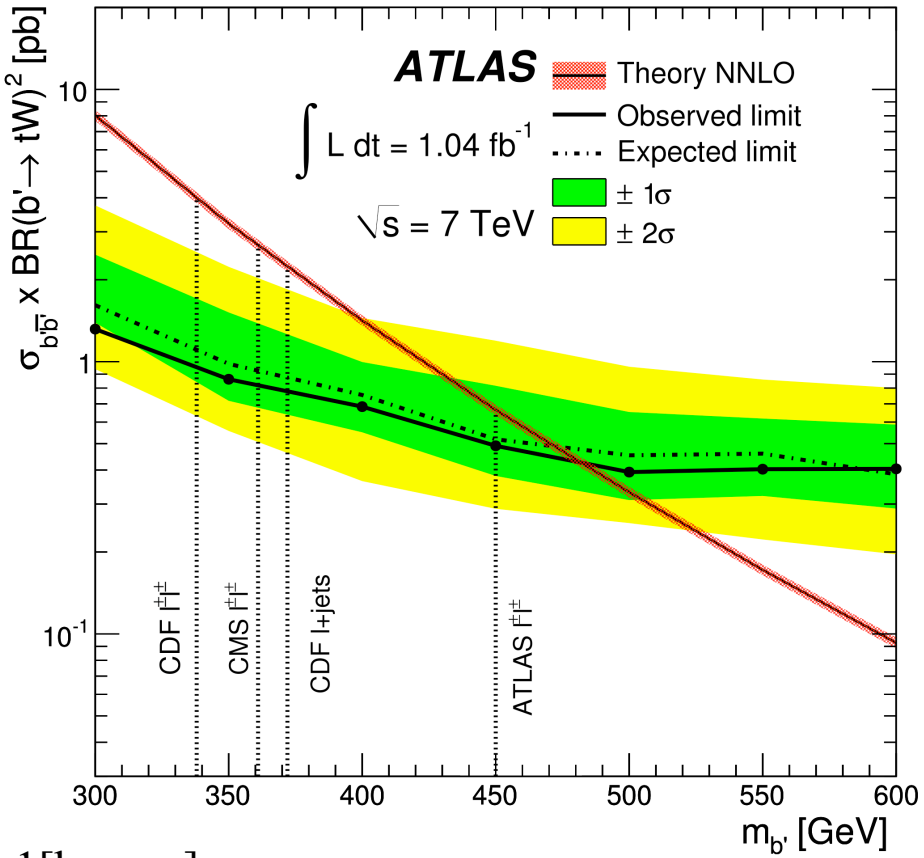
Here: cross section limits as a function of b' mass. β characterizes the fraction of signal events with at least one b'. In VLS option, a vector-like singlet mixes with the third Standard Model generation.

arXiv:1204.1265v1 [hep-ex]

Search for down-type fourth generation quarks with one lepton and hadronically decaying W's.

$$b'\bar{b}' \rightarrow W^- t W^+ \bar{t} \rightarrow b\bar{b}W^+W^-W^+W^- \rightarrow \ell^{\pm}\nu b\bar{b}q\bar{q}q\bar{q}q\bar{q}$$

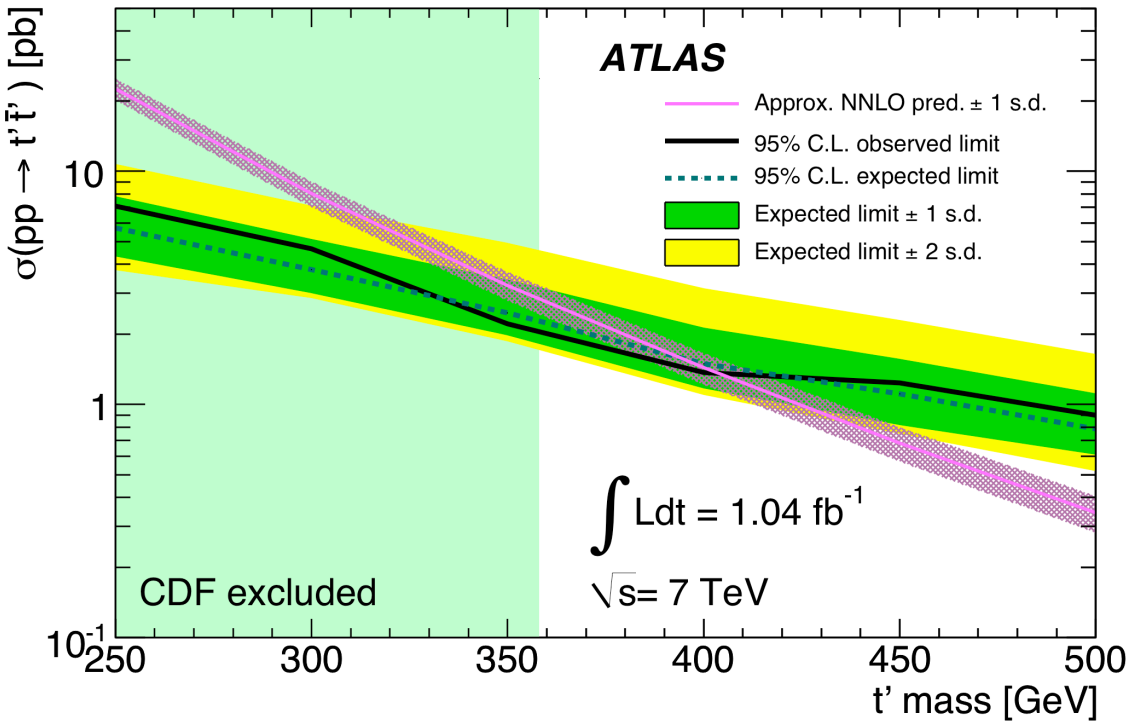




The lower limit on b' is raised to 480 GeV, significantly improved over the previous CDF limit of 372 GeV.

arXiv:1202.6540v1[hep-ex]

Search for pair production of a heavy quark decaying to W+b in the lepton + jets channel



Fourth generation t' enters theories as a source of CP violation to explain the matter-antimatter asymmetry or to motivate a heavy Higgs.

Sample: 1 high p_T isolated e or μ, high p_T^{miss}, and ≥ 3 jets.

Here: the 95% CL lower limit is now $m_{t'} > 404$ GeV.

arXiv:1202.3076v1[hep-ex]

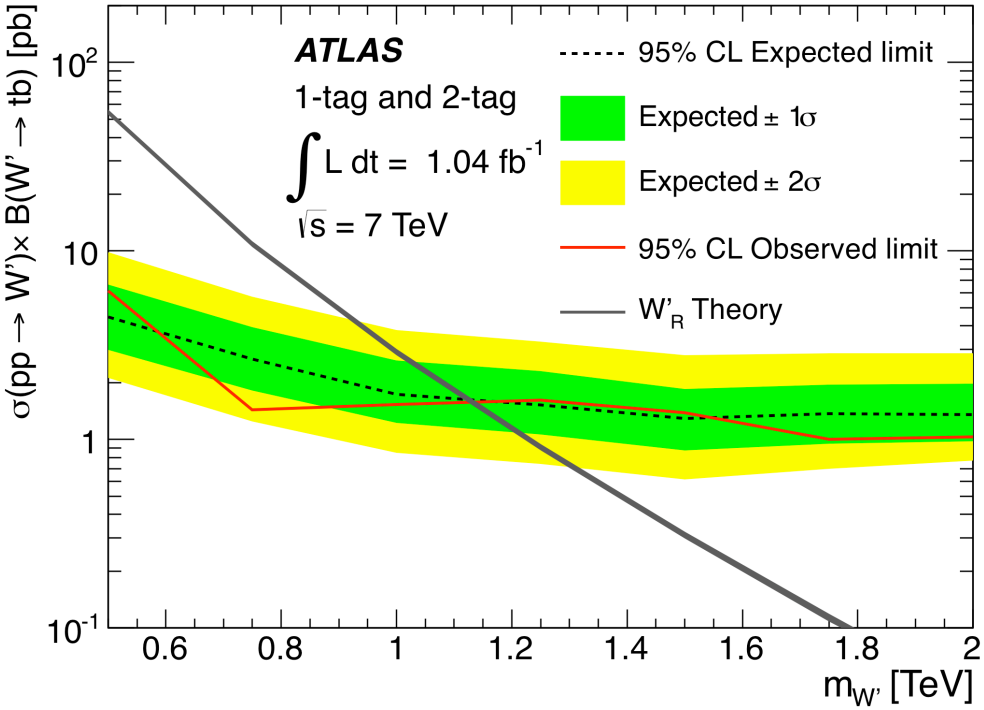
Search for tb resonances

Sample: $\ell + p_T^{miss} + 2j$

The most stringent direct limit on production of a right-handed $W_R' \to tb \to \ell\upsilon bb$:

$m_{W'} > 1.13$ TeV@95% CL

Here: upper limits on σ×BR are in the range (6.1 – 1.0) pb for $m_{W'}$ in the range (0.5 – 2.0) TeV.

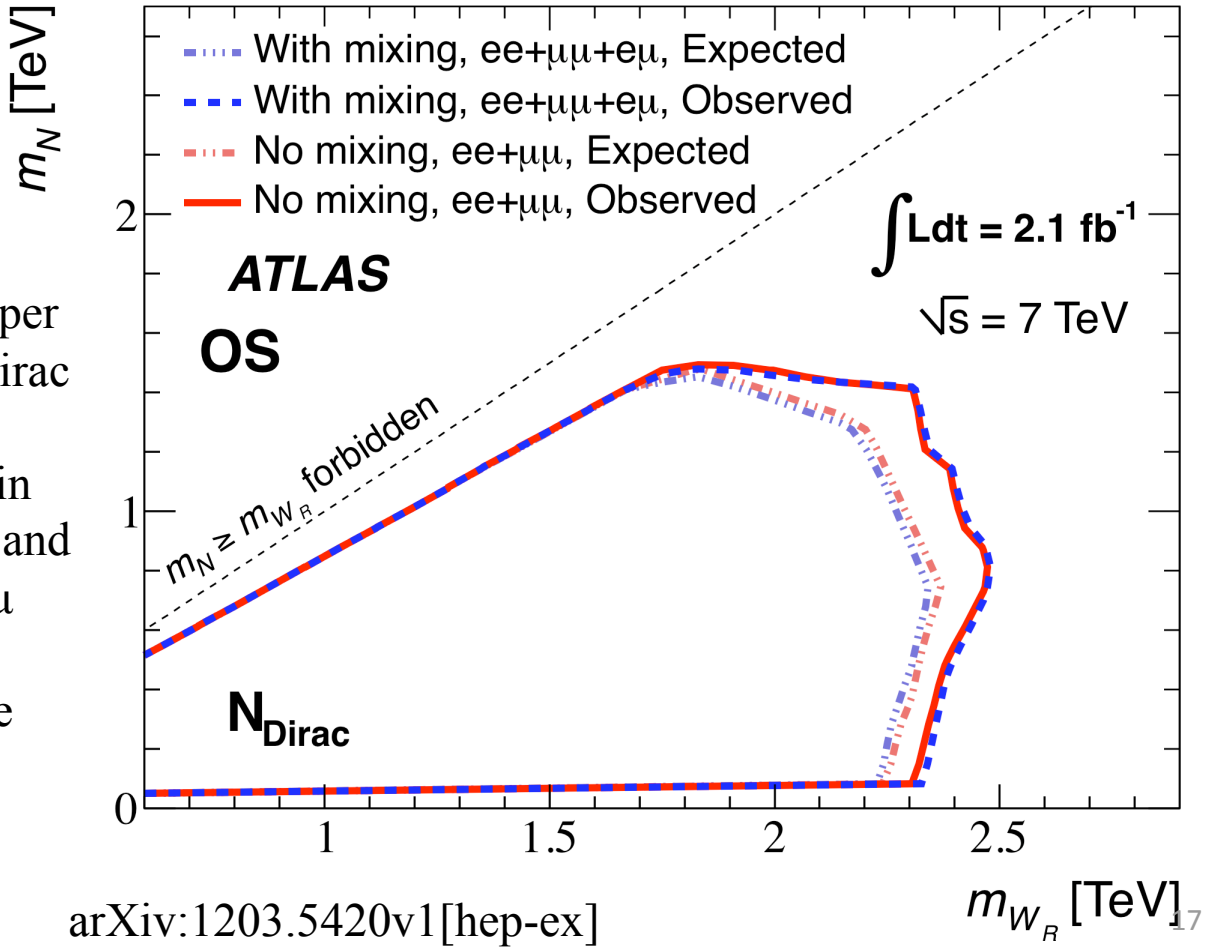


arXiv:1205.1016v1[hep-ex]

Search for heavy neutrinos and right-handed W_R

Sample: events with 2 high-p_T leptons + at least one high-p_T hadronic jet

Here: Example 95% CL upper limits on masses m_N of a Dirac heavy neutrino and masses m_{WR} of a gauge boson W_R in the scenarios of no-mixing and maximal-mixing of e and μ generations. These are the most stringent limits to date from direct searches.



arXiv:1203.5420v1[hep-ex]

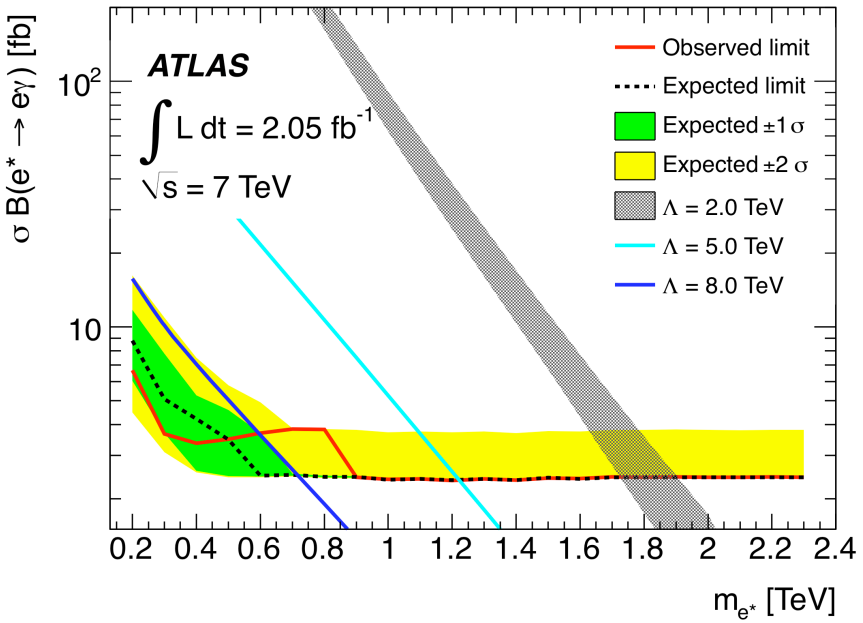
Search for excited leptons

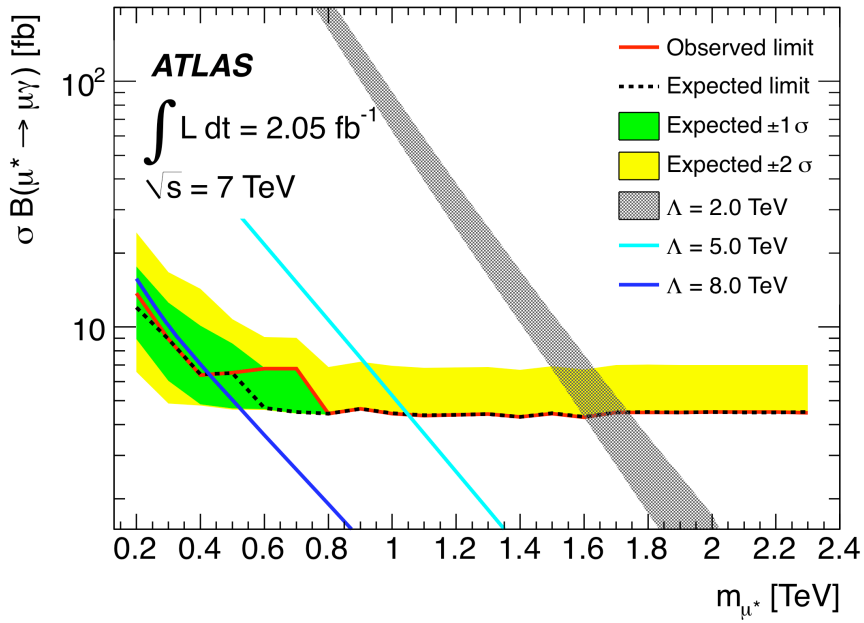
The sample: events with final state $\ell\bar{\ell}\gamma$ energetic, isolated, and well separated from each other.

95% CL limits are set on $\sigma \times BR(\ell^* \to \ell\gamma)$.

For $m_{\ell^*} > 0.9$ TeV, $\sigma \times BR < 2.3$ fb (e*) and < 4.5fb (μ*).

For compositeness scale $\Lambda = m_{\ell^*}$, these exclude masses < 1.87 TeV (e*) and < 1.75 TeV (μ*).





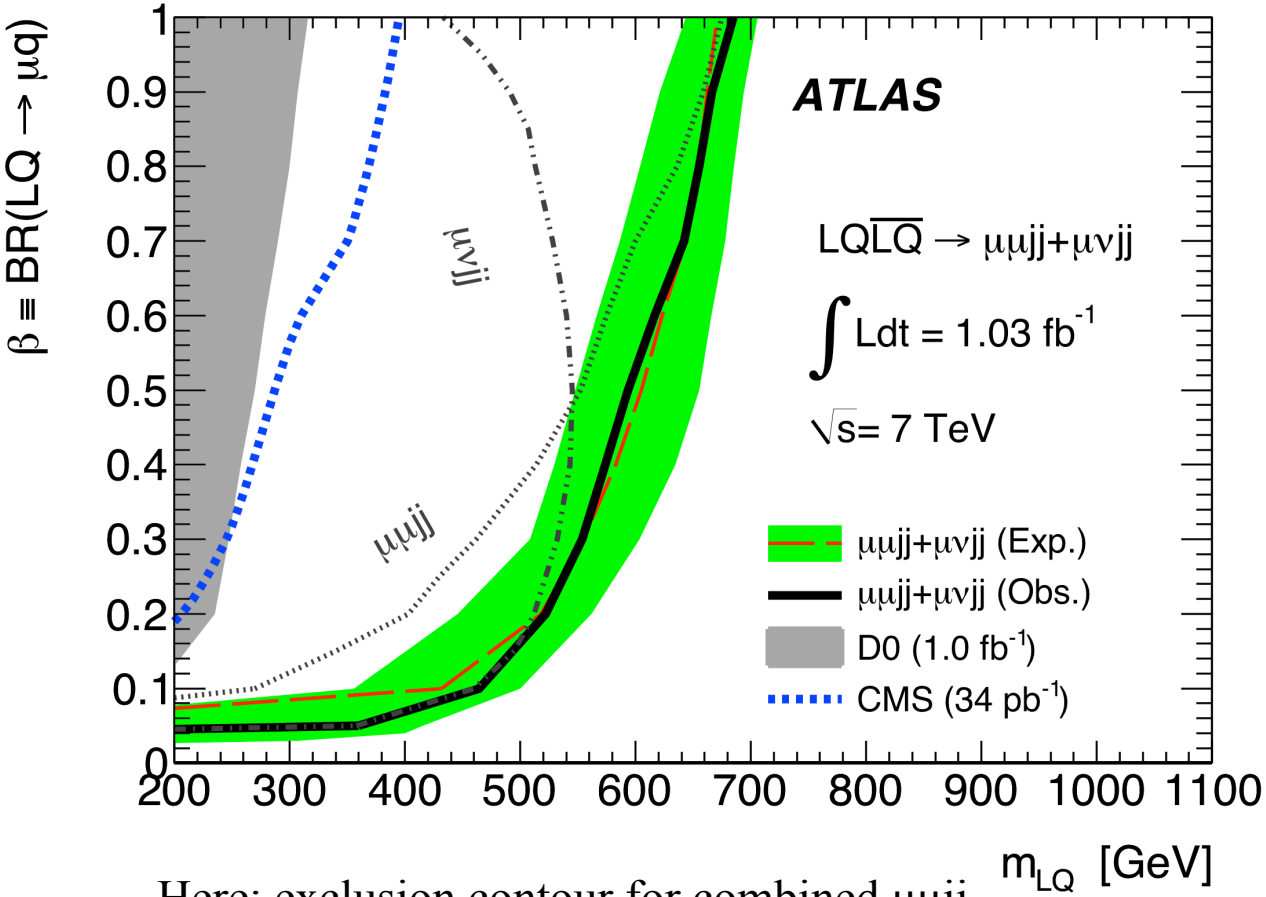
arXiv:1201.3293v2[hep-ex]

Search for second generation scalar leptoquarks

The sample: final states of μμ + at least 2 jets or μ + E_t^{miss} + at least 2 jets.

Excluded mass range: $m_{LQ} < 594$ (685) GeV at 95% CL for BR of 0.5 (1.0) for LQ decay to μ+q.

These are the most stringent limits arising from direct search.



Here: exclusion contour for combined μμjj and μνjj channels.

arXiv:1203.3172v1[hep-ex]

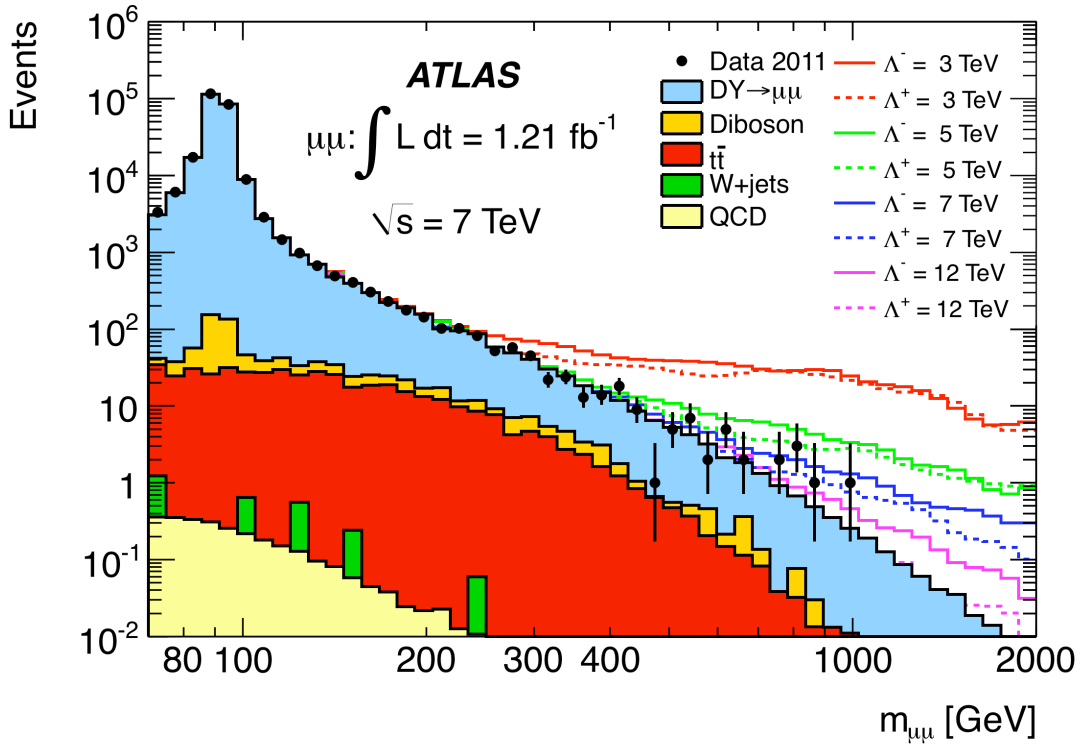
Search for contact interactions

Uses dilepton events in $q\bar{q} \rightarrow Z/\gamma^* \rightarrow \ell^+\ell^-$

With a prior flat in $1/\Lambda^2$ (Λ is the energy scale below which fermion constituents are bound), 95% CL limits are set on these energy scales of contact interactions:

electron channel: $\Lambda^- > 10.1$ TeV, $\Lambda^+ > 9.4$ TeV

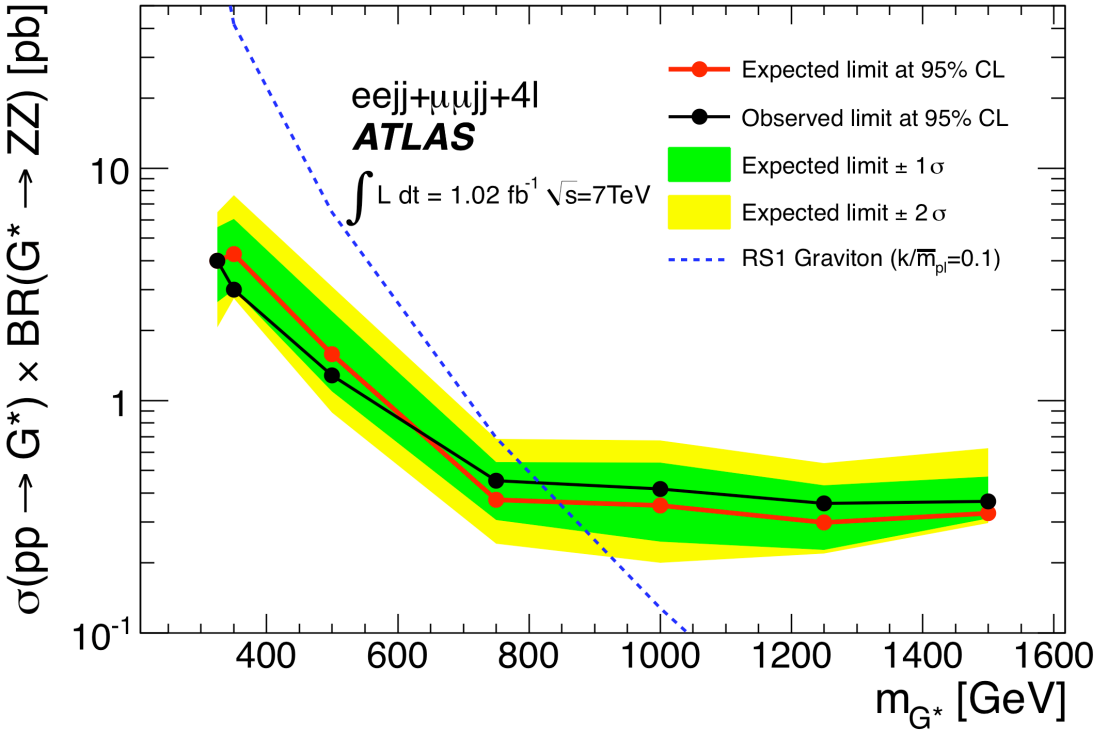
muon channel: $\Lambda^- > 8.0$ TeV, $\Lambda^+ > 7.0$ TeV



Here: The muon channel limits are the most stringent to date.

arXiv:112.4462v2[hep-ex]

Search for new particles decaying to ZZ using final states with leptons and jets: the Randall-Sundrum graviton



The sample: events containing 4 charged leptons or 2 charged leptons + 2 jets.

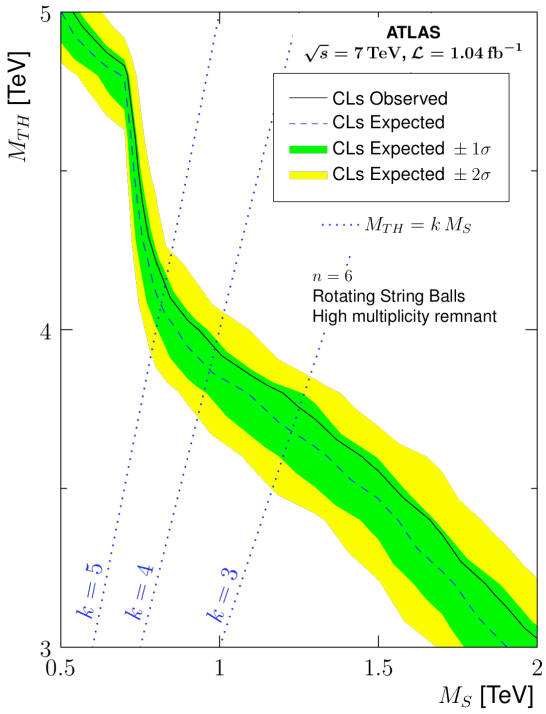
Here: RS1 graviton is excluded at 95% CL in the mass range 325 – 845 GeV for $k / \bar{m}_{planck} = 0.1$ (k is the curvature scale of the warped extra dimension, $\bar{m}_{planck} = m_{planck} / \sqrt{8\pi}$).

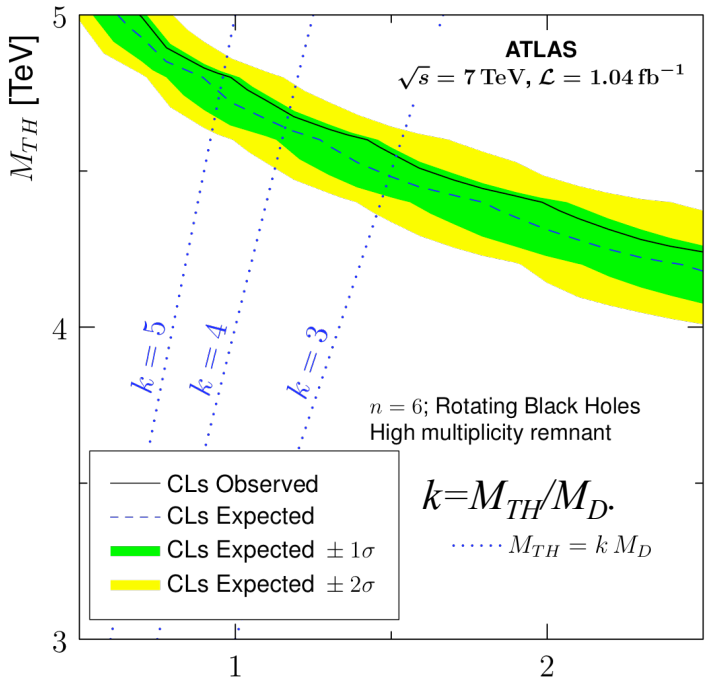
arXiv:1203.0718v1[hep-ex]

Search for TeV-scale gravity signatures: microscopic black holes and string balls

Final states with multiple high p_T particles including charged leptons and jets

Here: example exclusion limits in the plane of M_{TH} (minimal threshold) versus M_S (string scale) for rotating string balls with 6 extra dimensions. Prediction by CHARYBDIS.





Here: example exclusion limits in the plane of M_{TH} (minimal threshold) versus M_D (Planck scale in n+4 dimensions) for rotating black holes with 6 extra dimensions. Prediction with BLACKMAX.

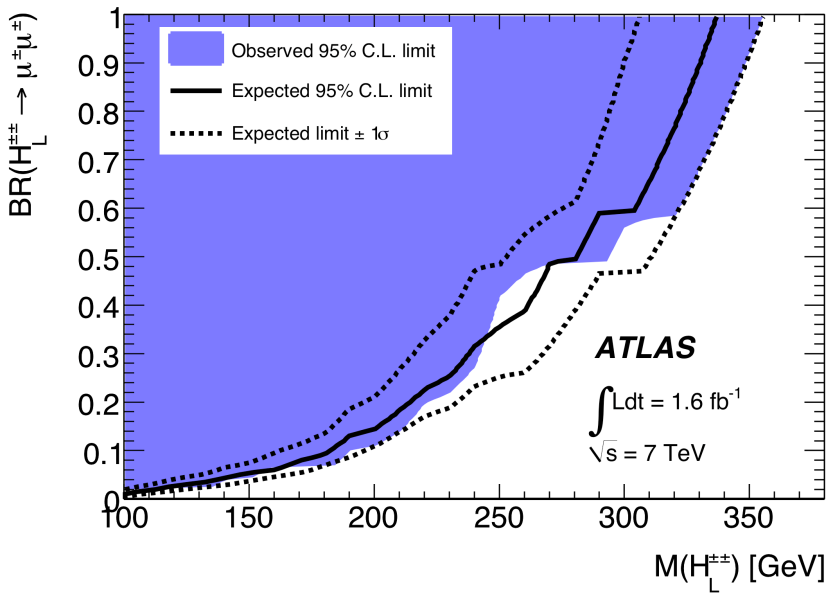
arXiv:1204.4646v1[hep-ex]

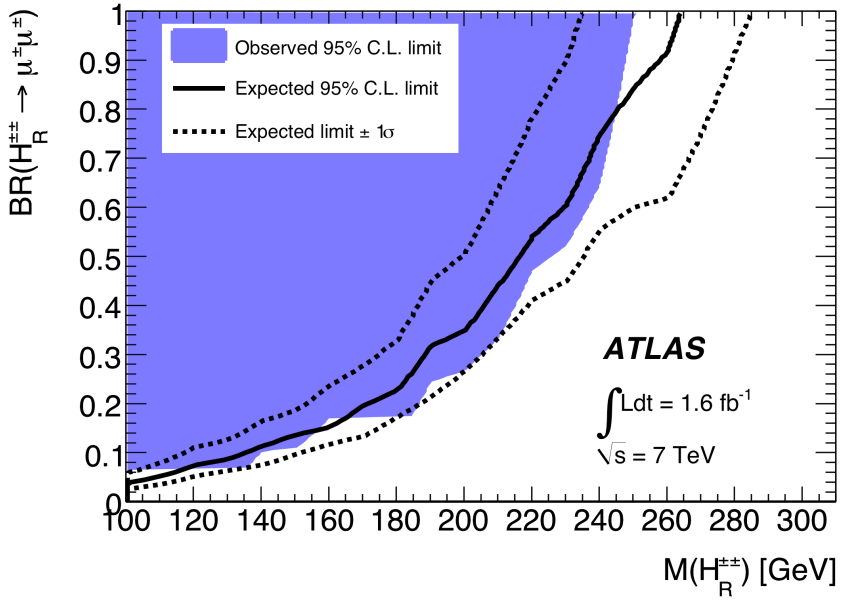
Search for anomalous production of like-sign muon pairs

Prompt pairs of like-sign leptons appear in many BSM theories.
Among these, theories of doubly-charged Higgs predict a narrow resonance.

Here: limits on production cross section for H^{++} range from 5.3 fb to 58 fb for the m(μμ) range 300 – 15 GeV. Each μ has $p_T > 20$ GeV and $|\eta| < 2.5$.

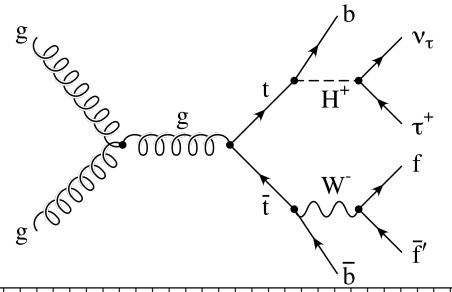
m > 355 GeV (if H^{++} couples to lefthanded fermions)
m > 251 GeV (if H^{++} couples to righthanded fermions)





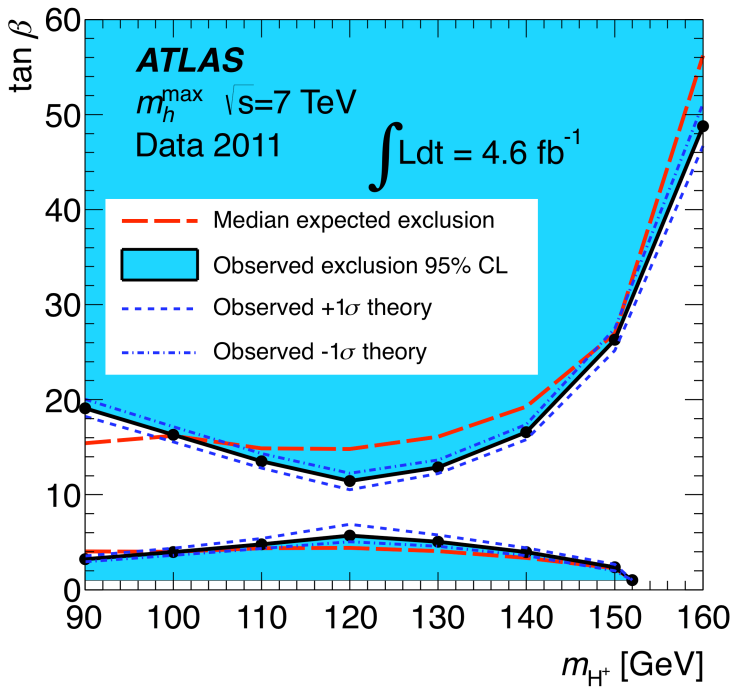
arXiv:1201.1091vw[hep-ex]

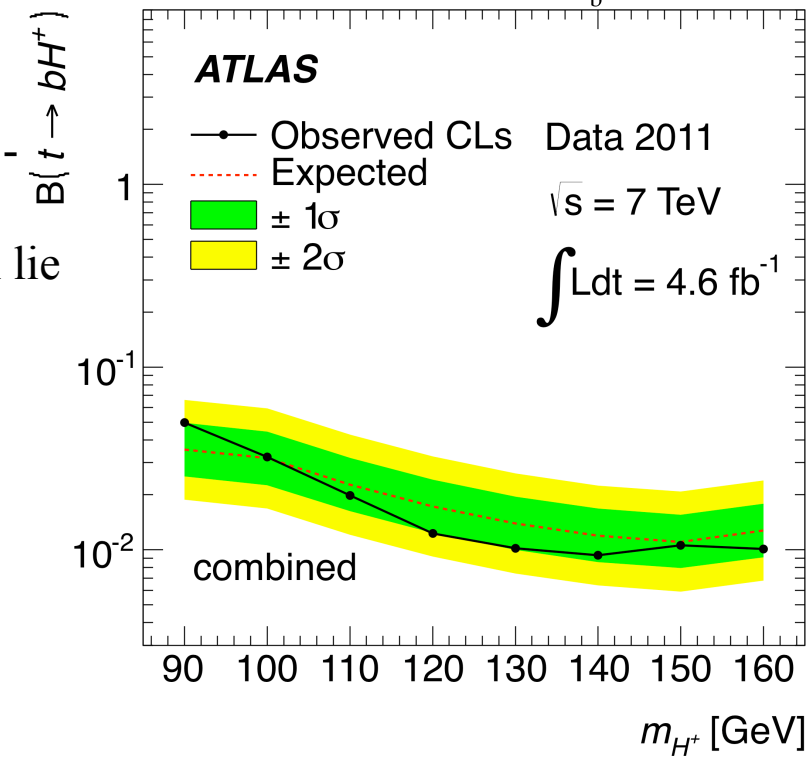
Search for charged Higgs $H^+ \to \tau\upsilon$ in $t\bar{t}$ events



Higgs

Sample: top events with a final state τ.
Assuming $H^+ \to \tau\upsilon$ BR=100%, this result, consistent with the Standard Model, implies $t \to H^+b$ BR upper limits in range 5% - 1% for m_{H+} range 90 – 160 GeV. Substantial improvement over Tevatron upper limits, which lie in the 15-20% range for $m_{H+} < m_{top}$.





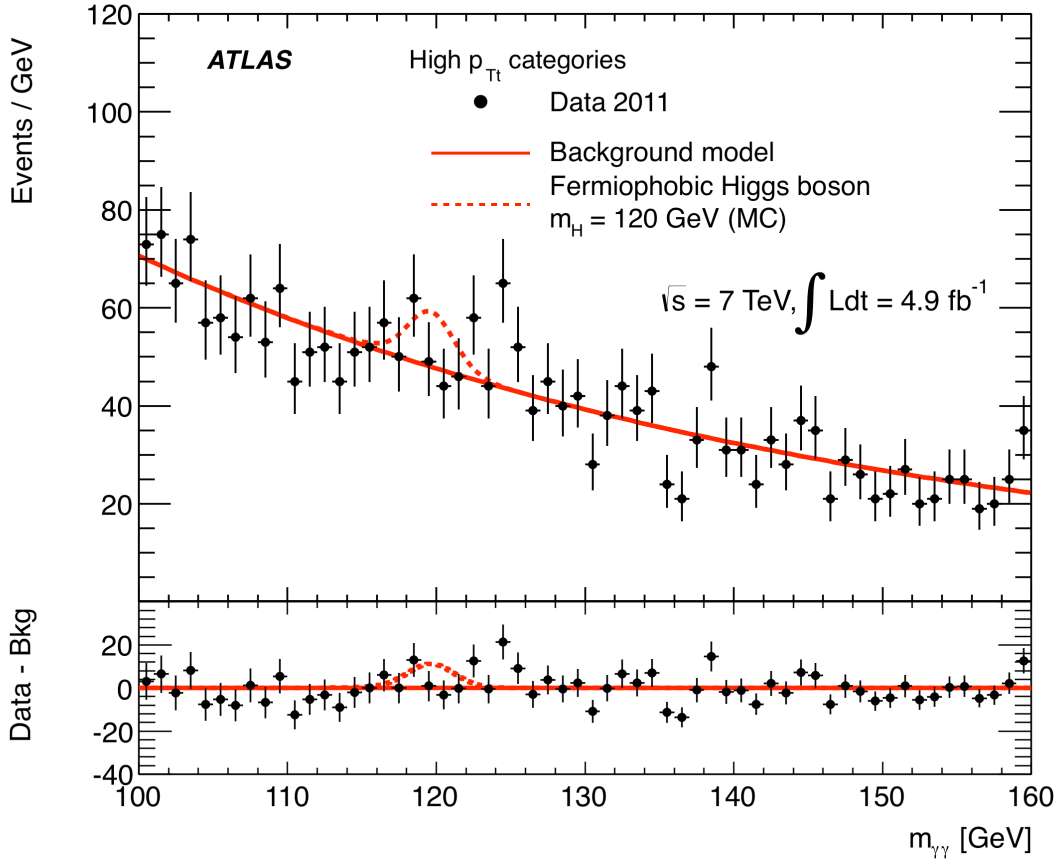
In MSSM, tanβ above 12-26 or between 1 and 2-6 is excluded for 90 GeV < m_{H+} < 150 GeV.

arXiv:1204.2706v1[hep-ex]

Search for a fermiophobic Higgs

Several extensions to the Standard Model include Higgs with 0 coupling to fermions and Standard Model coupling to bosons.

Excess at 125.5 GeV in the diphoton channel, significance 2.9 σ, (1.6 σ including 'Look Elsewhere Effect': the probability for a statistical fluctuation of this size to be found anywhere within a reasonable mass range). Masses in the ranges 110.0-118.0 and 119.5-121.0 GeV excluded at 95% CL.

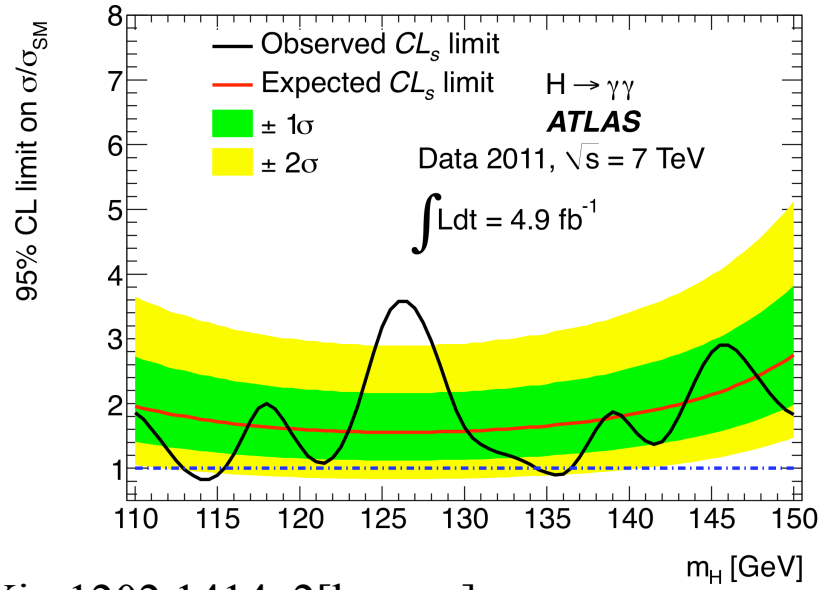


Here: diphoton invariant mass for events in the 'high p_T (>40 GeV)' categories, sum of background-only fits, and signal expectation for a mass 120 GeV Higgs.

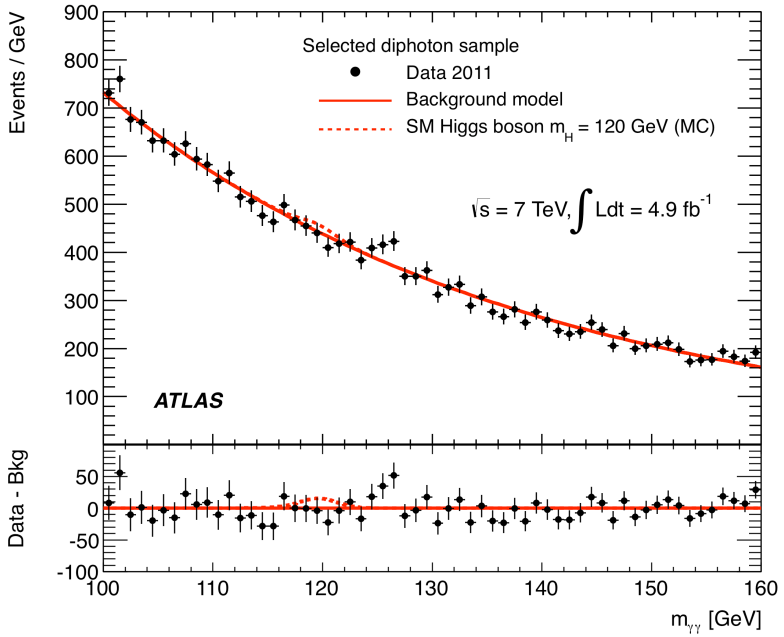
arXiv:1205.0701V1 [hep-ex]

Search for the Standard Model Higgs in the diphoton decay channel

- Each photon has $E_T \geq 20$ GeV.
- To optimize sensitivity, events are separated into 9 mutually exclusive categories with different mass resolutions and S/B ratios.
- Backgrounds: misidentified jets and Drell-Yan electrons that pass photon selection.
- Signal is simulated with full detector simulation including GEANT4 and pile-up.



arXiv:1202.1414v2[hep-ex]



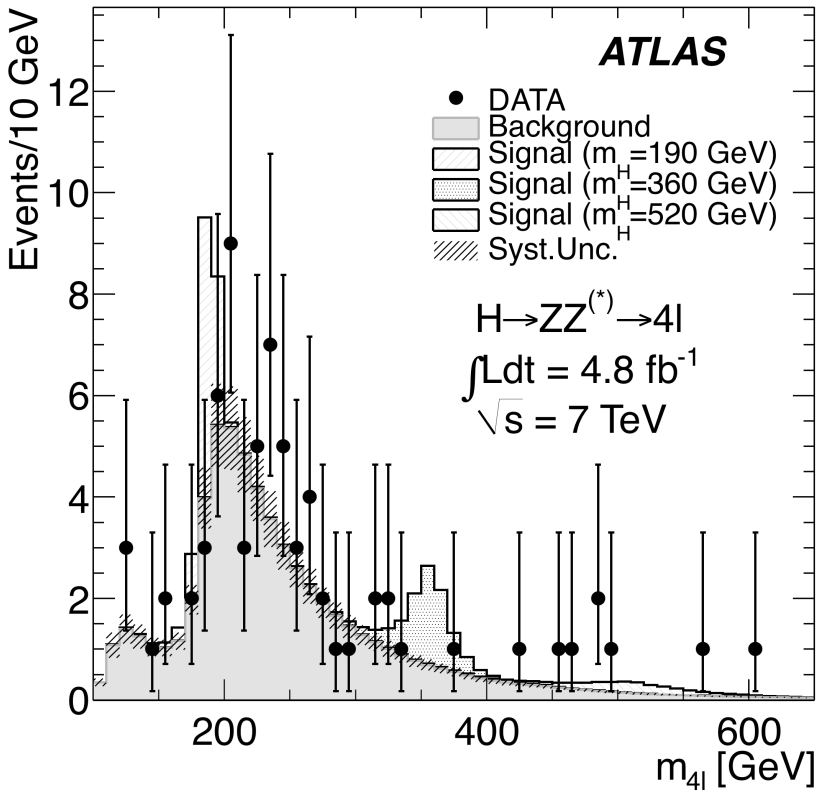
Excess at 126.5 GeV has significance 2.8σ, reduced to 1.5σ when Look Elsewhere is applied over range 110-150 GeV.

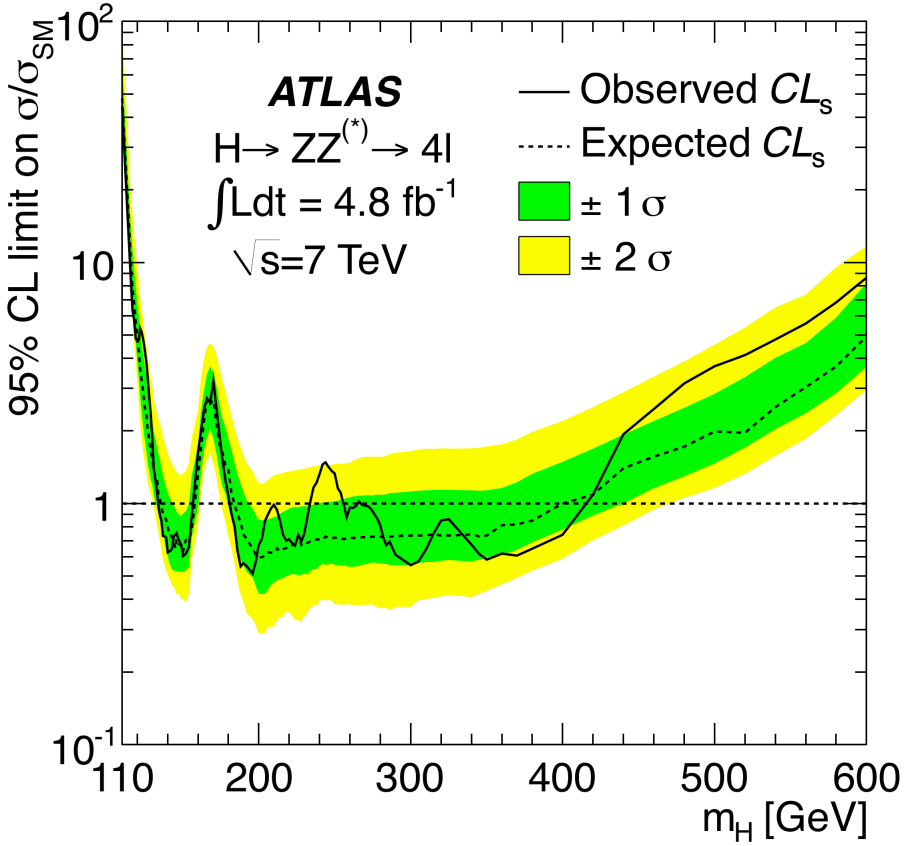
Search for the Standard Model Higgs in the channel

$$H \to ZZ^{(*)} \to 4\ell$$

4ℓ : $\ell^+\ell^-\ell'^+\ell'^-$, where

$\ell,\ell' = e$ or μ.

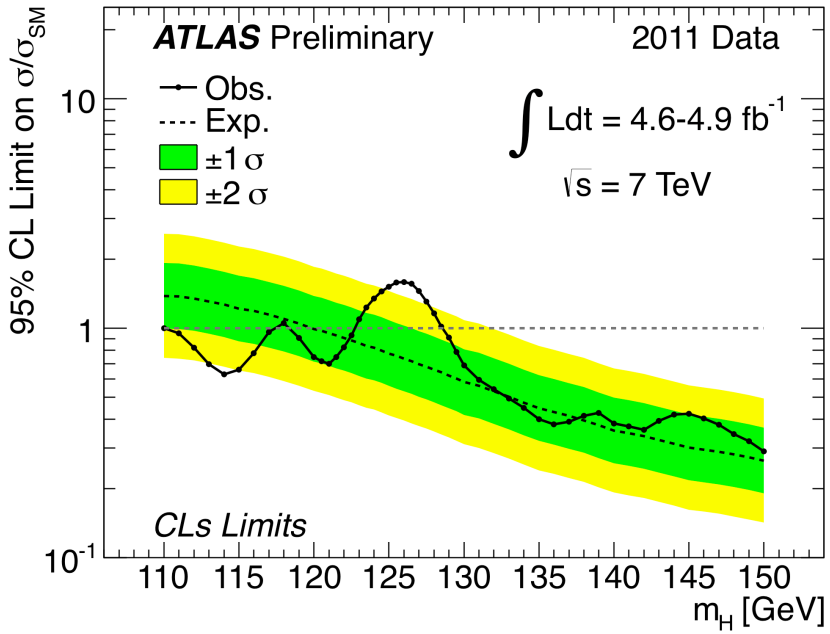


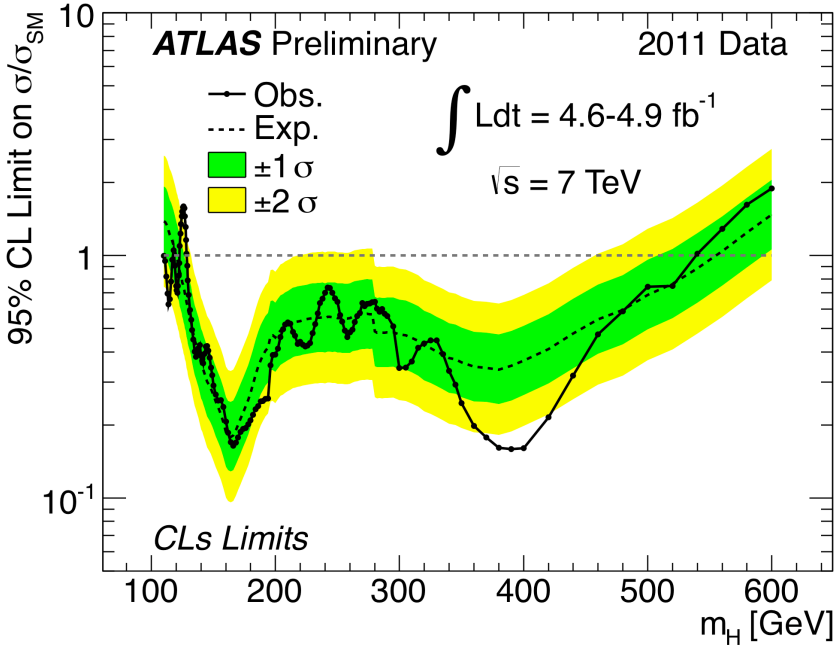


Excesses are observed at 125 GeV (2.1σ), 244 GeV (2.2σ), and 500 GeV (2.1σ). Adding the Look Elsewhere Effect reduces all of these to insignificance.

Combined search for the Standard Model Higgs

Including $H \to \gamma\gamma$, $H \to ZZ^{(*)}$, $H \to WW^{(*)}$, $H \to b\bar{b}$, and $H \to \tau^+\tau^-$, the significance at 126 GeV is 2.5 σ. The expected significance in the presence of a SM Higgs with $m_H = 126$ GeV is 2.9σ.





Mass ranges 110.0-117.5, 118.5-122.5, and 129-539 GeV are excluded at 95% CL. The global probability for an excess of this size is 30% over the range 110-600 GeV and 10% over the range 110-146 GeV.

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Conclusions

Results from a representative sample of 24 ATLAS physics analyses have been shown. These include:

- searches for new physics: new quarks, excited leptons, heavy neutrinos, gravity signatures, new intermediate bosons, leptoquarks, FCNC single top, and contact interactions

- Higgs searches and hints: fermiophobic, neutral, singly, or doubly charged, in electromagnetic channels

- Standard Model measurements: s-quark density of the proton, charge asymmetry in top pairs, two-particle angular correlations, γ+jet production cross section, azimuthal ordering of charged hadrons

Every week brings new light in long-dark corners, new records on stringent tests, the hoped-for, and the unexpected.