# Recent results from the ATLAS experiment

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On behalf of the ATLAS Collaboration

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- The ATLAS detector
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  - Performances
- Physics highlights
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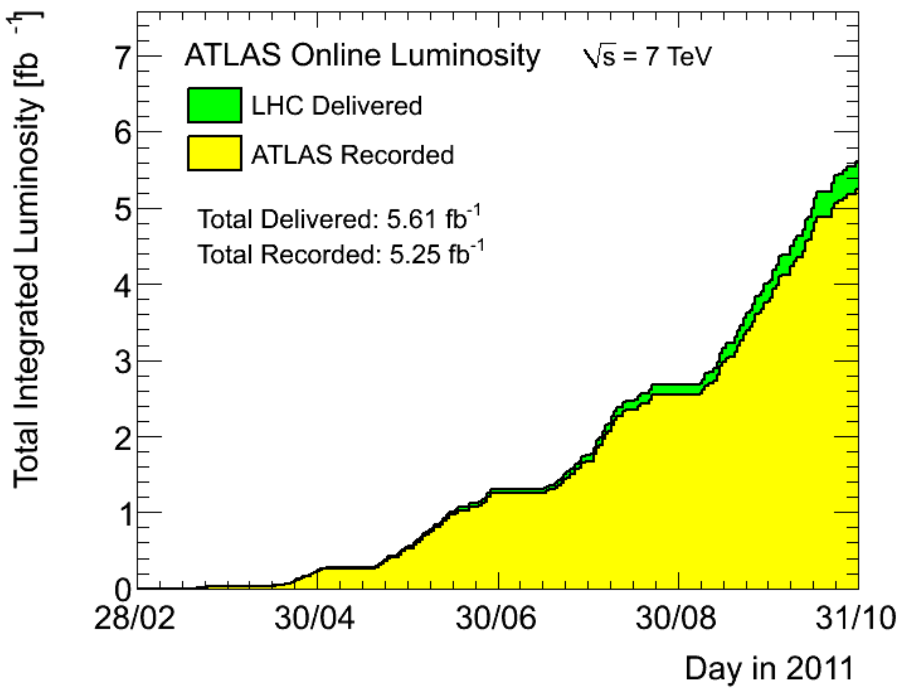
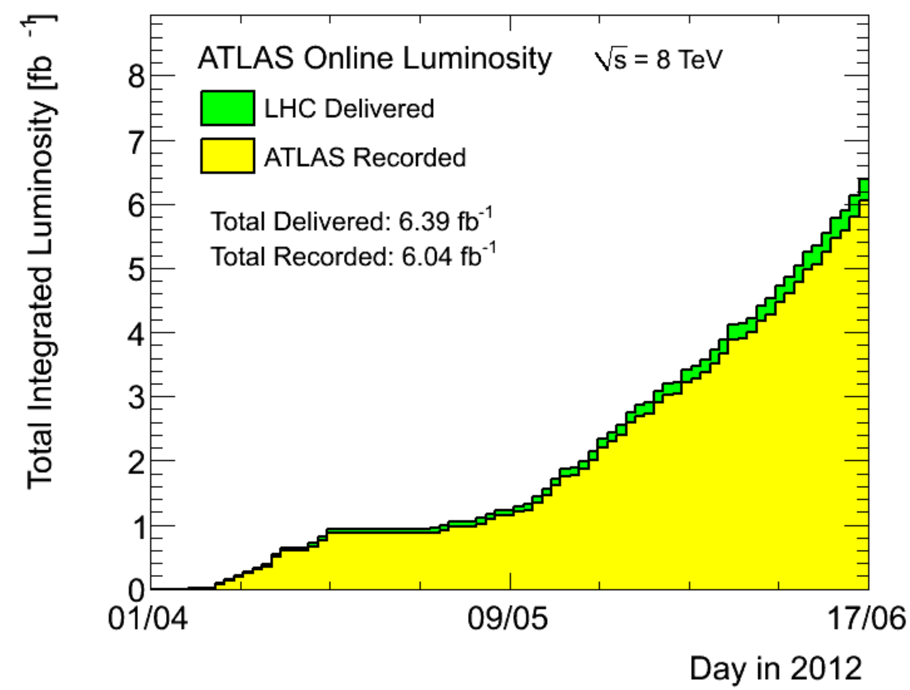
  - Higgs
    - High mass
    - Low mass
  - SUSY
  - Exotics
- Conclusions

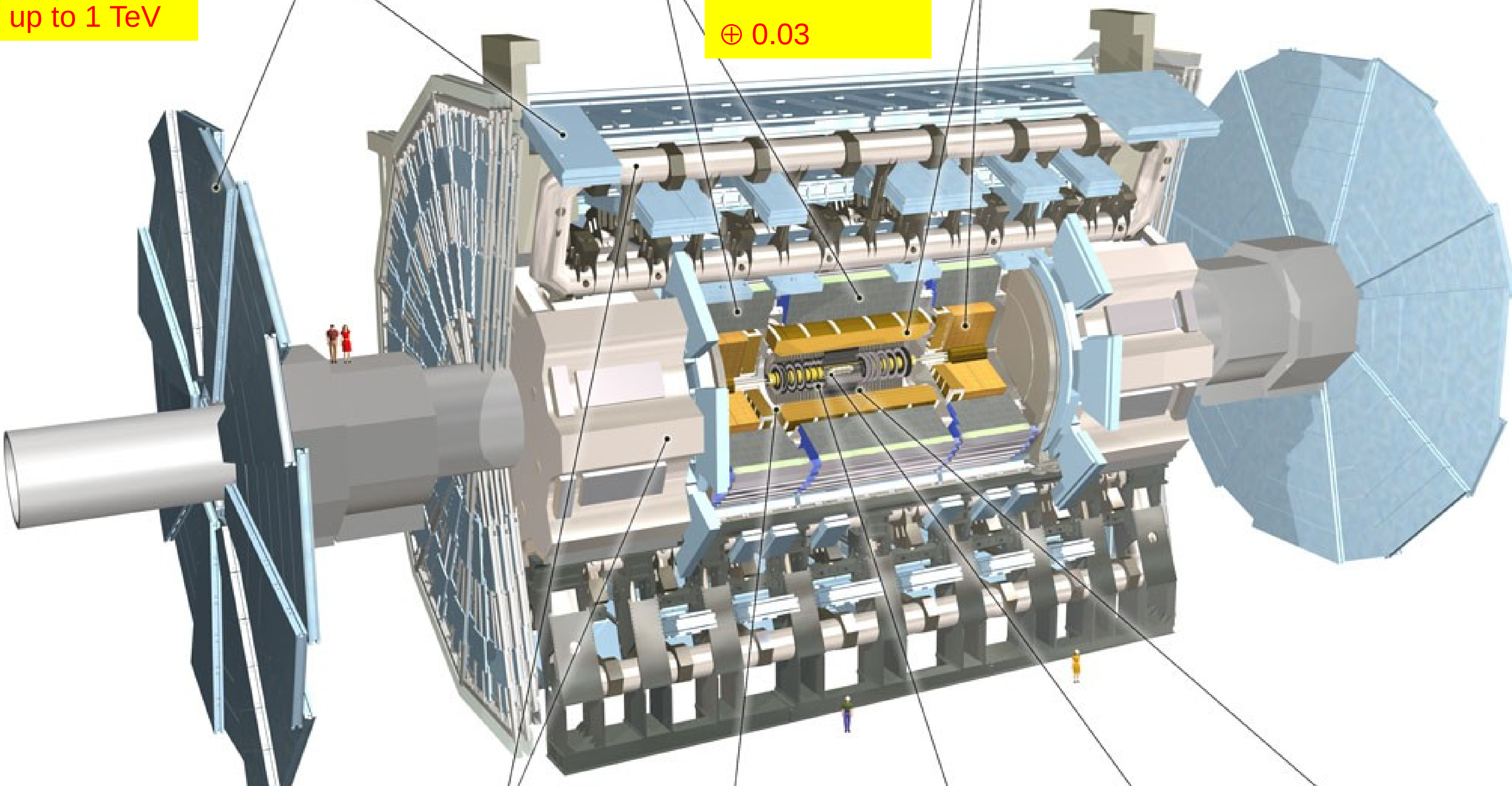
# Introduction




- Startling LHC performance in 2011
  - 5.61/fb @7TeV delivered, peak stable luminosity $3.65 \times 10^{33} cm^{-2}s^{-1}$
- Very promising beginning of the 2012 run
  - 5.39/fb @ 8TeV delivered, peak stable luminosity $6.76 \times 10^{33} cm^{-1}s^{-1}$
- Data is processed promptly, and analyses are digesting it as fast as possible (while also studying detector performance, trigger efficiencies, ...)
  - A large amount of interesting results already presented/published
  - Will give here an overview of some of our latest public results (on 2011 data)

# *The ATLAS detector*




Tracking: overall resolution $\Delta p_t/p_t$ <= 0.05% $p_T$(GeV) ⊕ 1%

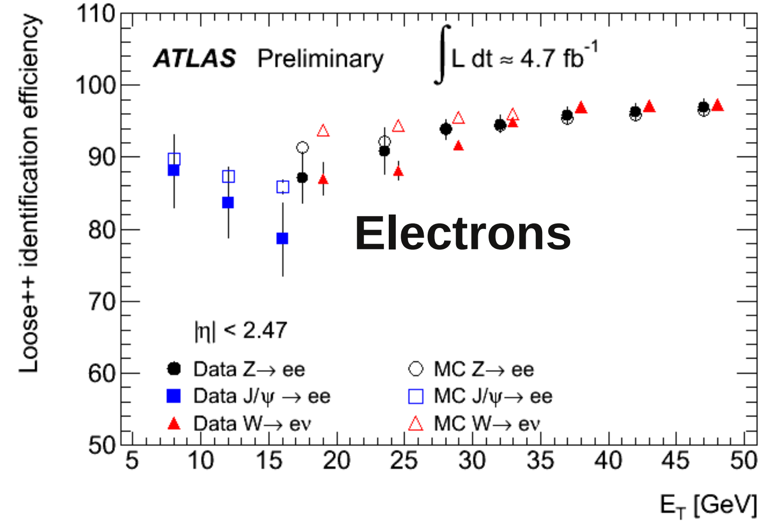
# The ATLAS detector (2)

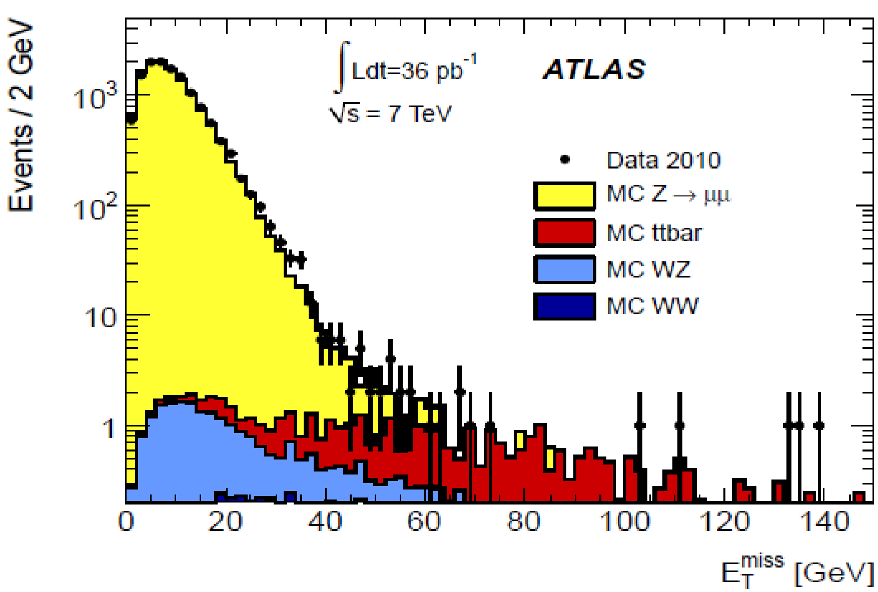
- The size of the detector is reflected in the size of the collaboration designing/building/operating it and analyzing its data
  - ~3000 scientists from ~170 institutes, from ~40 countries
- In spite of the intrinsic complexity, the detector is operating very well, with sub detectors operational status close to 100%, and data taking efficiency >90%

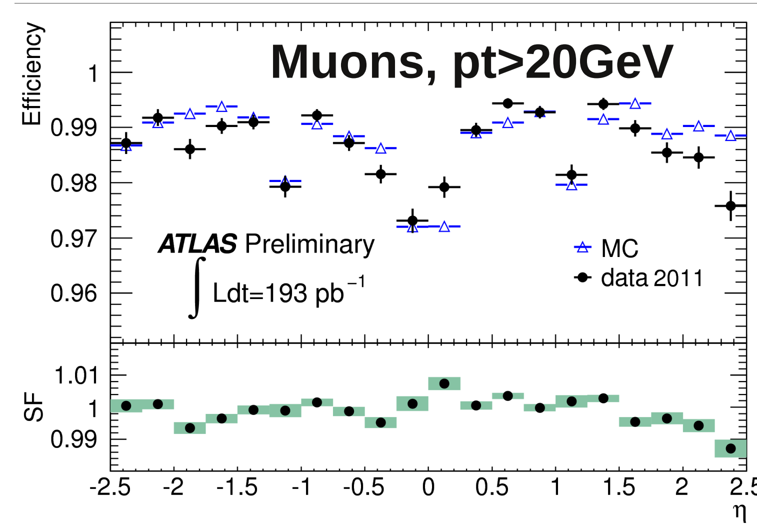

| Subdetector | Number of Channels | Approximate Operational Fraction |
|---|---|---|
| Pixels | 80 M | 95.9% |
| SCT Silicon Strips | 6.3 M | 99.3% |
| TRT Transition Radiation Tracker | 350 k | 97.5% |
| LAr EM Calorimeter | 170 k | 99.9% |
| Tile calorimeter | 9800 | 99.5% |
| Hadronic endcap LAr calorimeter | 5600 | 99.6% |
| Forward LAr calorimeter | 3500 | 99.8% |
| LVL1 Calo trigger | 7160 | 100% |
| LVL1 Muon RPC trigger | 370 k | 99.5% |
| LVL1 Muon TGC trigger | 320 k | 100% |
| MDT Muon Drift Tubes | 350 k | 99.7% |
| CSC Cathode Strip Chambers | 31 k | 97.7% |
| RPC Barrel Muon Chambers | 370 k | 97.1% |
| TGC Endcap Muon Chambers | 320 k | 99.7% |

# Detector performance

- Reconstruction and tracking efficiencies as measured from data are very close to their expected value from simulation
  - “Tag&Probe” exploits invariant mass constraints on particle pairs from resonances, together with two independent tracking systems, to measure the efficiency of one tracker wrt the other



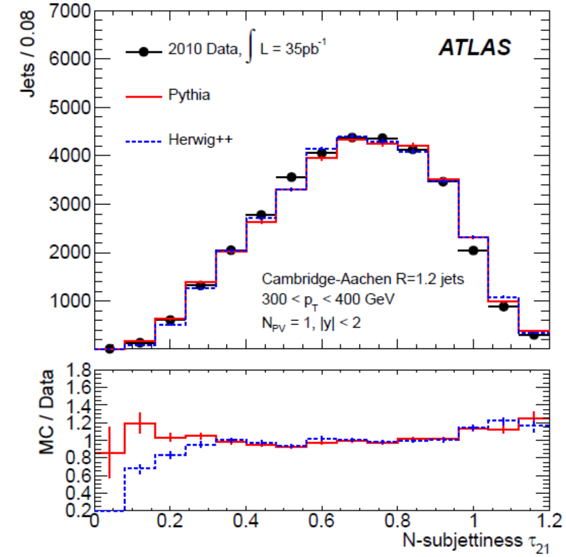



# Standard Model

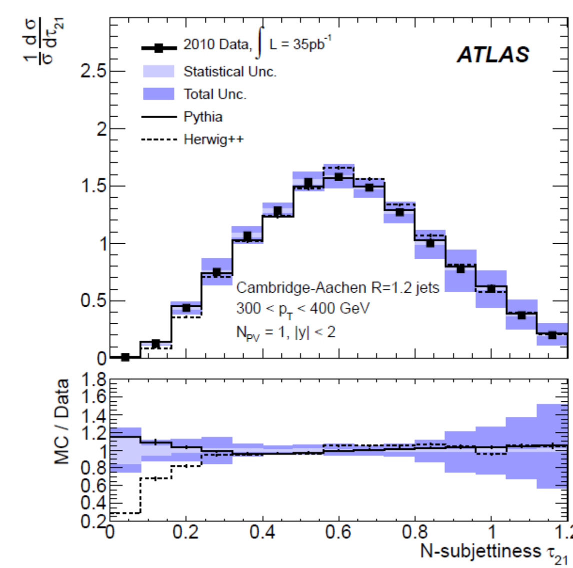
# Jet substructure

- Check if parton-shower describes correctly the inner structure of jets
  - Useful for decays of boosted heavy particles
- Split-and-filter procedure to identify jets with a relatively hard, symmetric substructure
- Observables include
  - Kt splitting scales: uses the kt distance of the final and penultimate clustering step to derive information about “hardness” of the decay and its symmetry
    - Can distinguish heavy particles from q/g splittings
  - N-subjettiness: how similar a given jet is to an aggregation of N subjets
    - Forces kt algorithm to look for N constituents, measures how well the jet constituents are collimated around the resulting subjet axes
- Challenge is the modeling of the calorimeter response
  - Scale uncertainties of each substructure variable are constrained in-situ using track-jets
    - Limits are ID tracking efficiency and MC modeling of neutral/charged jet components
      - Overall, scale uncertainties are in the range 3-6%
  - (conservative) resolution uncertainties taken from MC (10%-20%)




Detector level

Detector effects and acceptance unfolded



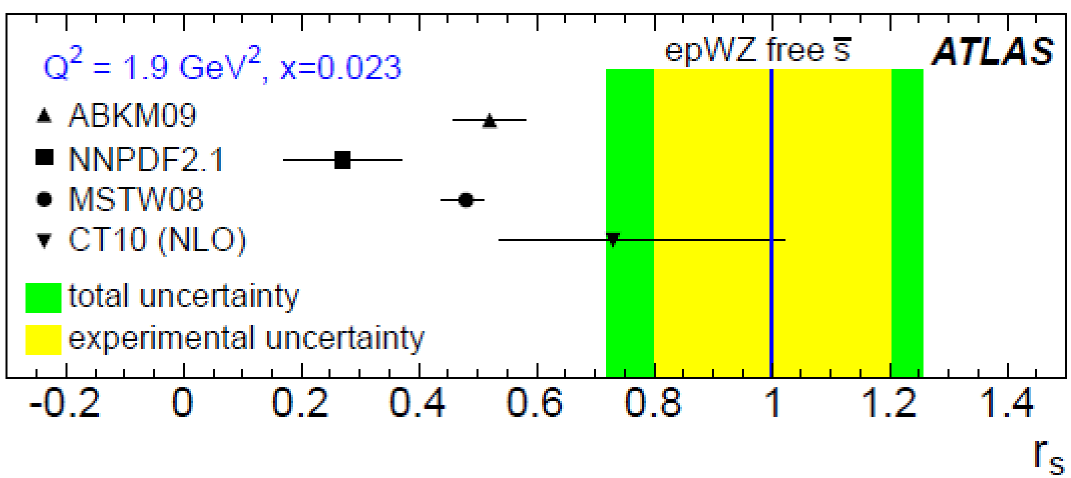
Dibosons in backup

# W/Z cross section

- We have reached the point where we can start constraining the PDFs using our measurements
- Very interesting study on the s-quark PDF
  - Flavor SU(3) symmetry suggests light sea quark distributions to be equal
    - Still, larger mass may cause suppression of s quarks
- Ratio of W/Z cross sections in ATLAS sensitive to sea composition @ $Q^2 \sim m^2_{Z,W}$ and $0.001<x<0.1$
- Calculation performed at NNLO using ATLAS events plus DIS data from HERA
- Result favors s fraction close to d fraction in sea, i.e. larger than what most PDFs predict today

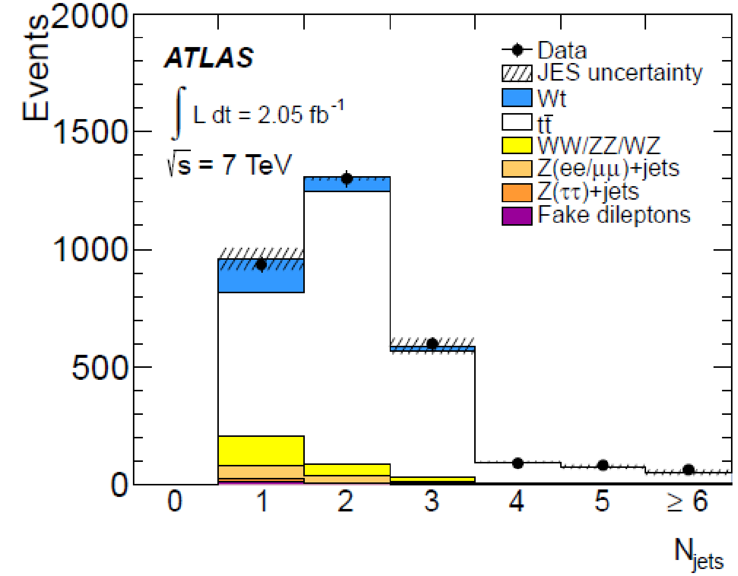
$$r_s = 0.5(s+\bar{s})/\bar{d}$$

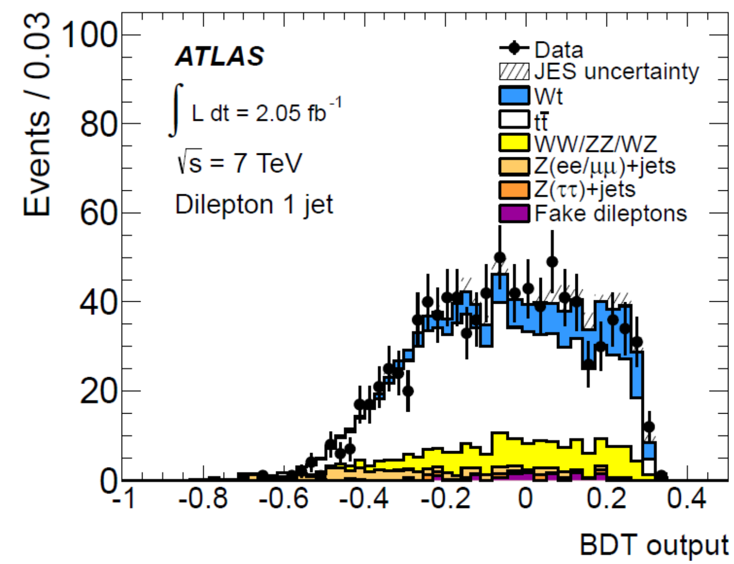
$$r_s = 1.00^{+0.25}_{-0.28}$$



# Wt production

- Direct probe of W-t-b coupling ($|V_{tb}|$)
- Final state with two Ws and one b
  - Signature is two opposite-sign, high-pt, isolated leptons, at least one jet, large Etmiss
    - Z-mass-veto on lepton pair, no b-tagging, bin results in number of jet
- Backgrounds
  - ttbar: MC-based, constrained by fit on data
  - Dibosons
  - Z+jets: data driven estimate, unc 10%-35%
  - Impact of fake leptons estimated from data. conservative unc of 100%
  - $Z \rightarrow \tau\tau$ MC prediction cross validated with data in CR (unc 60%)
- After selection, MV techniques (BDT) used to further discriminate signal from backgrounds
  - Template fit on MV output yields cross section measurement
- Main systematics: JES (~15%), parton shower (~15%), pileup (~8%)




$$\sigma_{Wt} = 16.8 \pm 2.9\ \text{(stat)} \pm 4.9\ \text{(syst) pb}$$

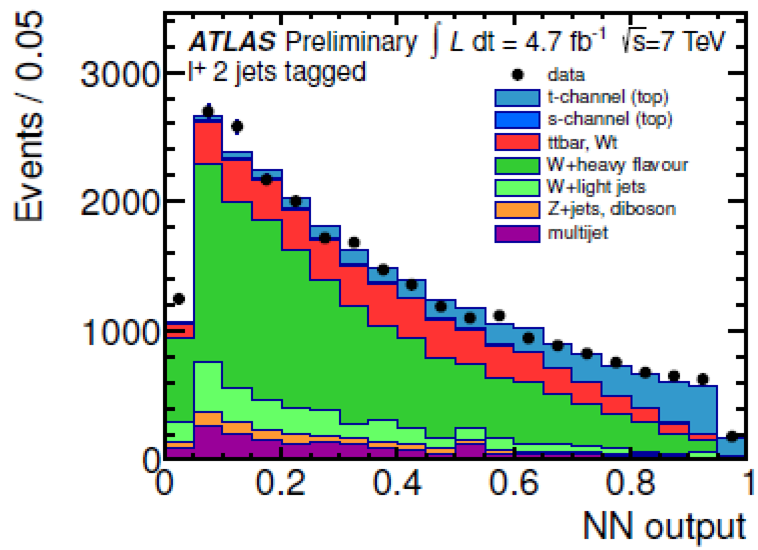
$$|V_{tb}| = 1.03^{+0.16}_{-0.19}$$

ttbar → $l+\tau_{had}+X$

in backup

# $R_t$

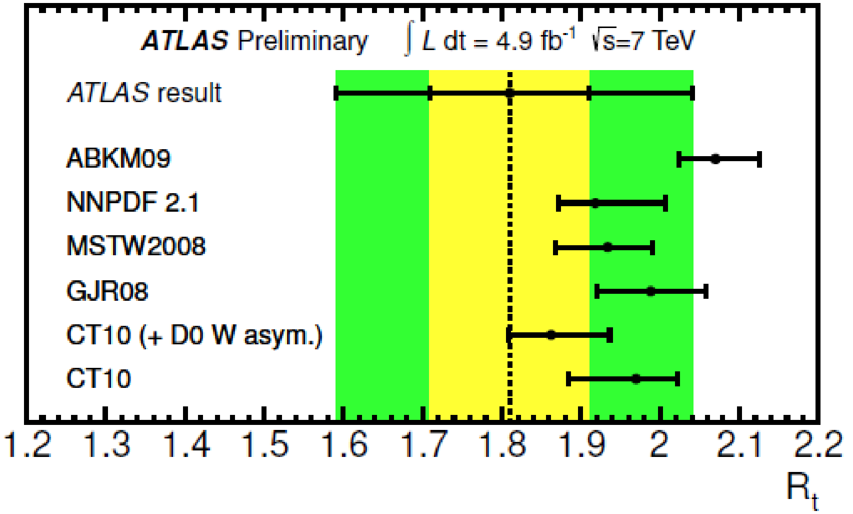
- Look for single-top production in t channel
  - Production of top expected to be larger than anti-top, due to different u,d PDFs in proton
  - Ratio of the top/anti-top production cross sections sensitive to u,d PDFs in 0.02<x<0.05
- Final state is W+b+u/d
  - Signature is one high-pt, isolated lepton with large Etmiss from W decay, 2/3 hard hadronic jets
- Main background is W+jets, estimated from data using MC-based shapes. QCD multijets estimated using template fit with data-driven shapes. Other backgrounds from MC.
- After selection, MV technique used to further discriminate signal from backgrounds
- Main systematics for $R_t$ are ISR/FSR (4.2%) multijet normalization (3.8%), JES (3.7%)




$$\sigma_t(t) = 53.2 \pm 1.7\,(\text{stat.}) \pm 10.6\,(\text{syst.})\,\text{pb} = 53.2 \pm 10.8\,\text{pb},$$

$$\sigma_t(\bar{t}) = 29.5 \pm 1.5\,(\text{stat.}) \pm 7.3\,(\text{syst.})\,\text{pb} = 29.5^{+7.4}_{-7.5}\,\text{pb} \quad \text{and}$$

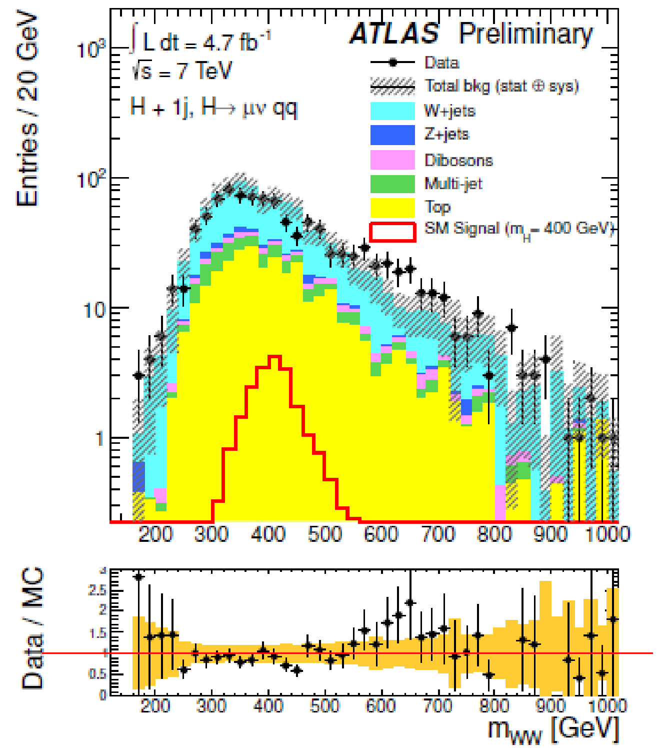
$$R_t = 1.81 \pm 0.10\,(\text{stat.})\,^{+0.21}_{-0.20}\,(\text{syst.}) = 1.81^{+0.23}_{-0.22}.$$

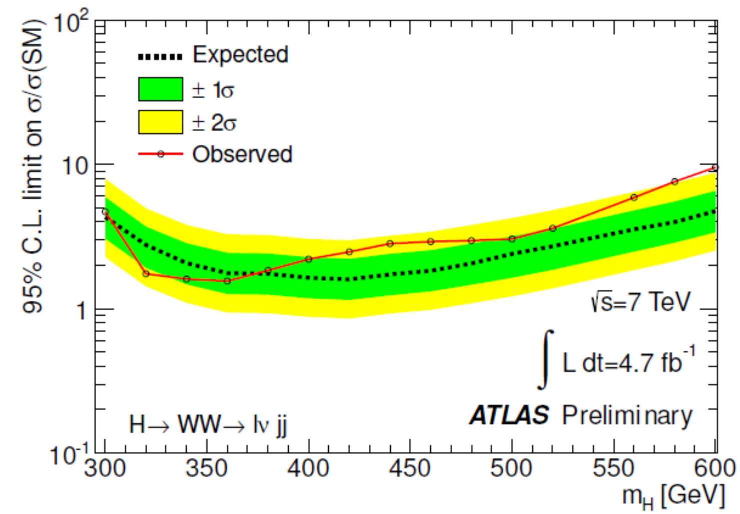


# *Higgs searches*

# $H \rightarrow WW \rightarrow l\nu jj$

- Limited to $m_H$>300GeV to better control backgrounds and to $m_H$<600GeV to avoid overlap between the two jets
- Look for lepton/Etmiss from W, two (b-vetoed) jets from W; allow 0/1 (sensitive to ggF) or 2 (sensitive to VBF) additional jets
- Dominant background is W+jets, but the limit-setting procedure does not use MC
  - Data-driven parameterization of the smooth background shape is used
- Systematics driven by signal reconstruction uncertainties: jet scale/resolution (8%/10%), Etmiss (10%-16% mainly due to pileup), b-tagging (7%)

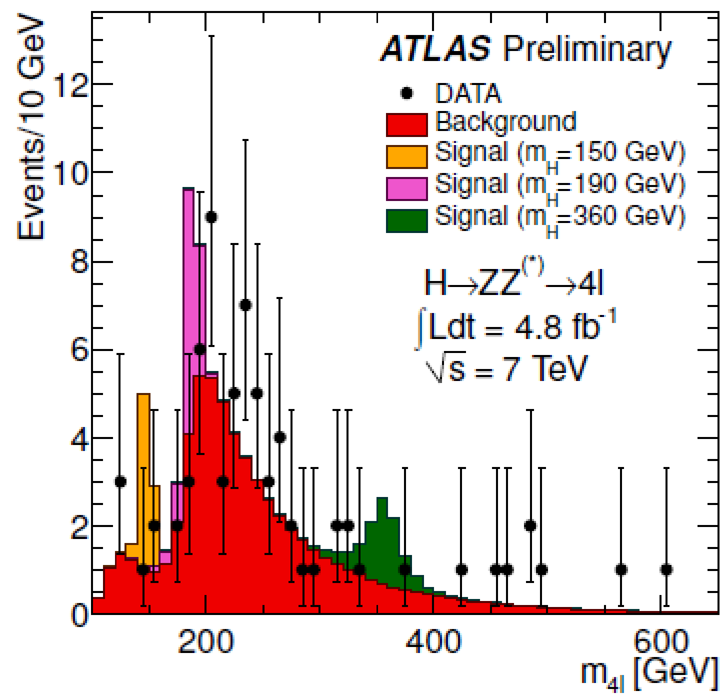


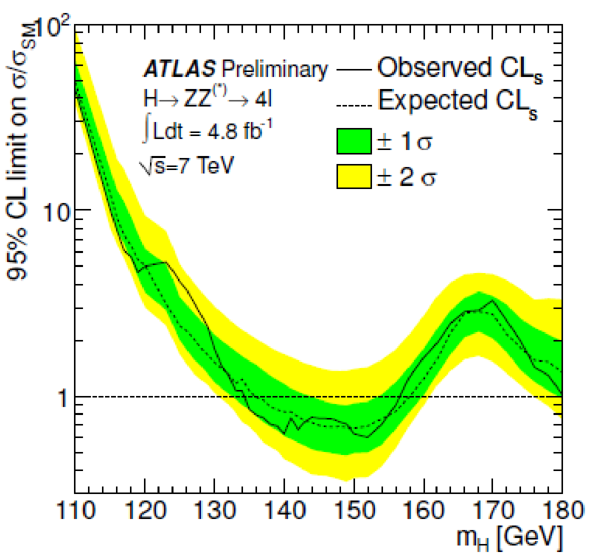
ZZ→llqq and llνν in backup

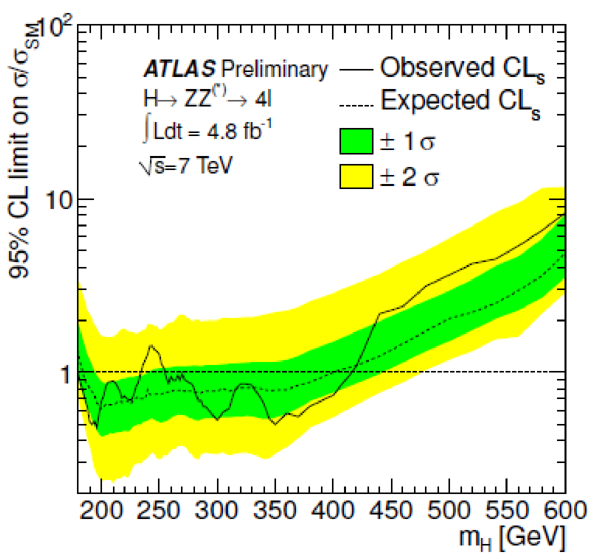
# $H \rightarrow ZZ \rightarrow 4l$

- Interesting over the whole mass range
- Main background is continuous ZZ(*) production
  - For $m_H$<180GeV, also ttbar and Z+jets become important
    - Z+bb for muons, Z+light jets for electrons
- ttbar normalized using different-flavour lepton pairs; ZZ(*) uses MC (15% syst unc); Z+jets normalized using data (45%-40% syst unc)



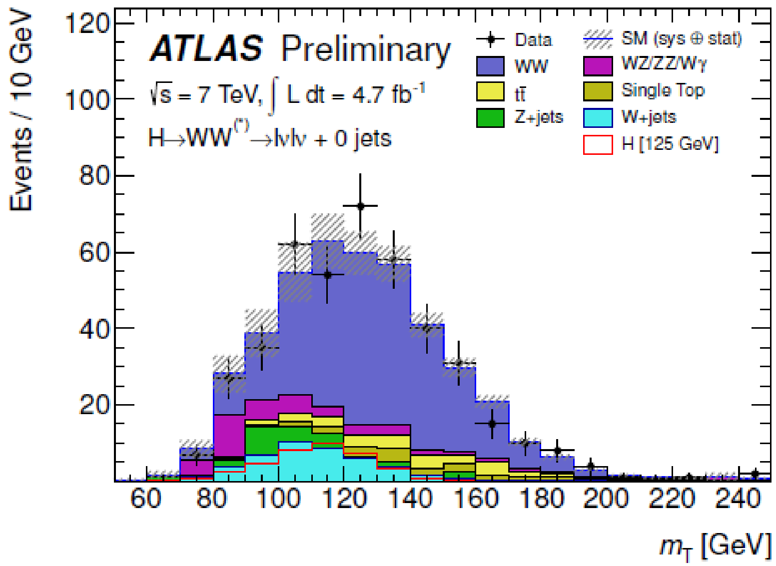

- Uncertainty on $m_{4l}$ due to electron scale from 0.3% to 0.6%
- Theoretical uncertainty on signal is 15%-20% for ggF and 3%-9% for VBF
- Expected exclusion: 137-158 GeV and 185-400GeV
  - **Observed: 135-156GeV, 181-234GeV and 255-415 GeV**
- **Excess significance is 2.1σ@125GeV, 2.3σ@244GeV, 2.2σ@500GeV**

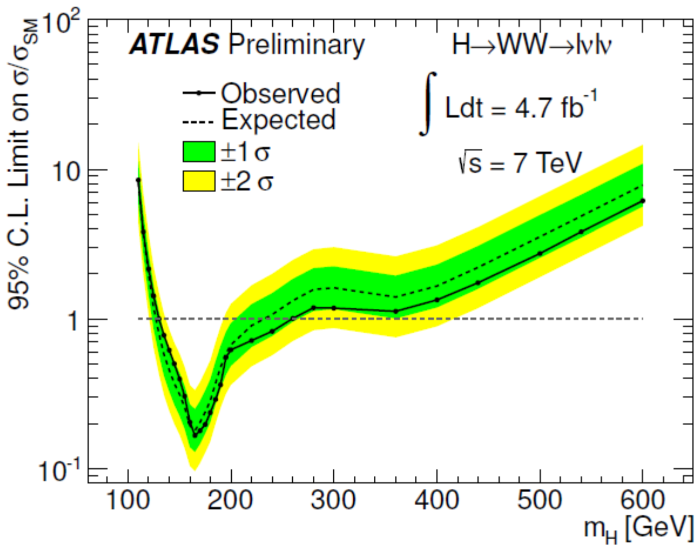


# $H \rightarrow WW \rightarrow l\nu l\nu$

- Look for two opposite-charge, isolated, high-pT leptons, off from the Z peak
  - Relative angle is required to be small for low mass searches, to exploit H→WW spin correlations
- Require large Etmiss
  - actual cut is on the component perpendicular to the nearest hard jet/lepton
- Split the analysis in different channels depending on the number of additional jets (sensitive to ggF vs VBF); veto b-jets to suppress ttbar events
- Backgrounds estimated from data using control regions: WW (syst unc 10%-24%); Z+jets (25%-56%); top (23%-30%); W+jets(30%-50%)
- Expected exclusion: 127-234GeV
  - **Observed: 130-260GeV**



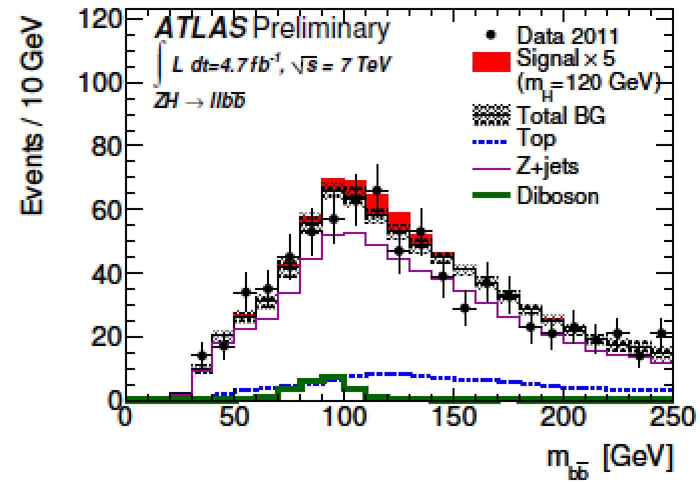



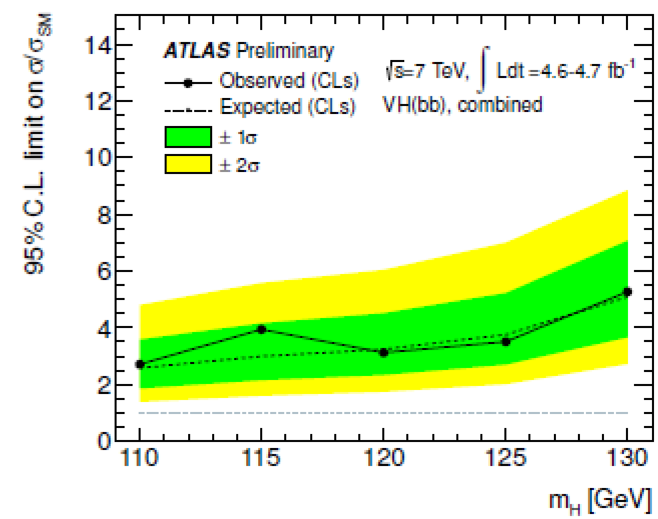
H → ττ

in backup

# $HV \to bbV$

- Exploit large BR of H→bb in the low mass region
  - Require associated production with W/Z to suppress QCD background
- Channels are ZH→llbb, WH→lνbb  and ZH→ννbb
- Analysis split in bins of pt of the vector boson
  - harder spectrum expected in signal than in bg
- Top, W+jets estimated normalizing MC shapes to data in control regions; QCD multijet uses templates from data
- Theory systematics are 5% for ZH and 11-13% for WH
  - due to QCD modeling of events with 3 or more jets
- Dominant experimental systematics on signal expectation are b-tagging (10%-20%) and JES/Etmiss (4%-11%)



# $H \to \gamma\gamma$

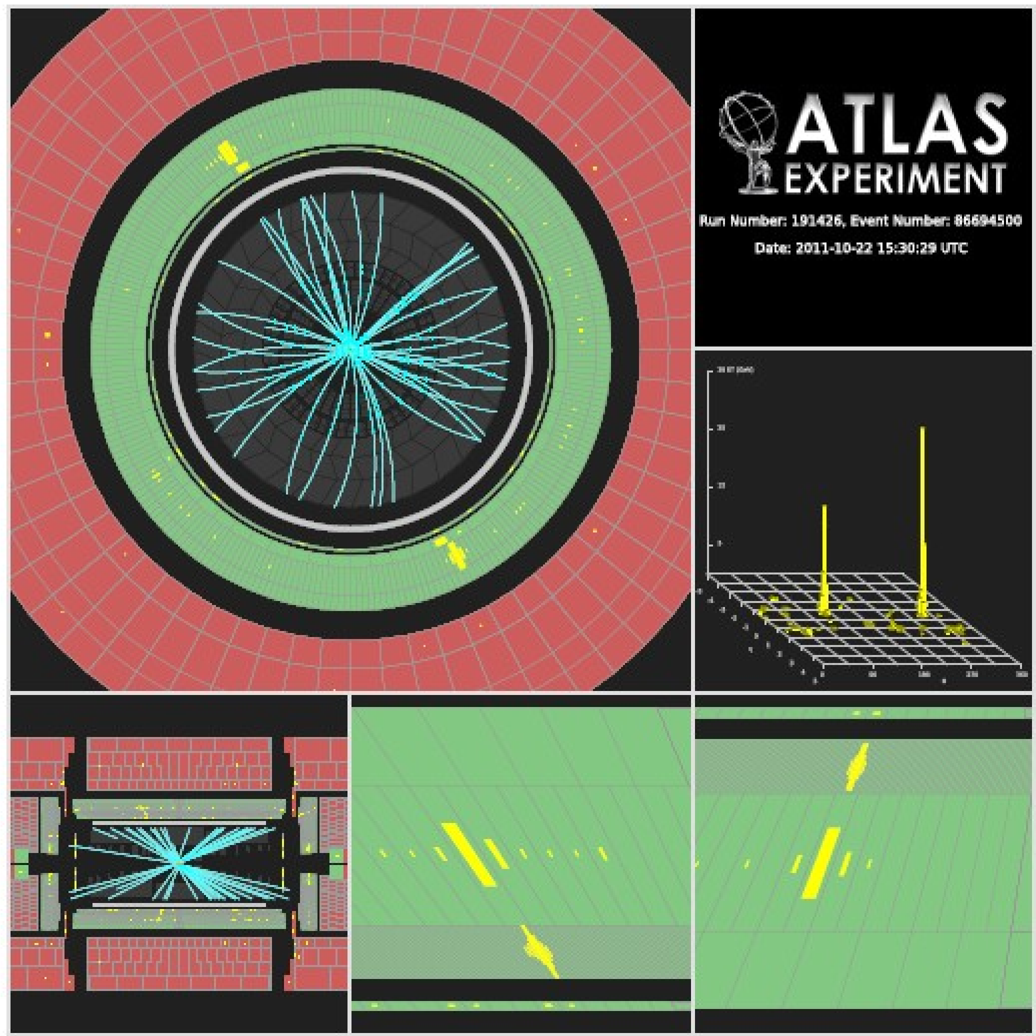
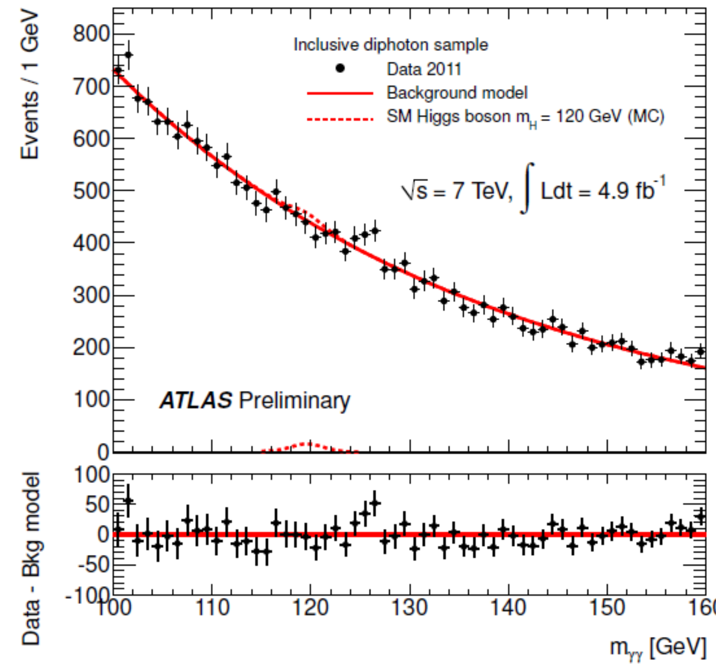
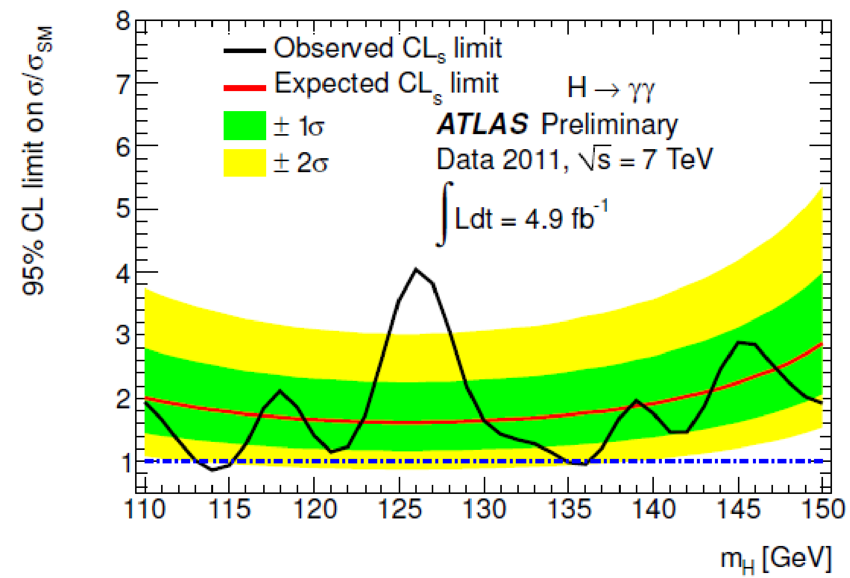



Figure 13: Event display of a candidate diphoton event where both photon candidates are unconverted. The event number is 86694500 and it was recorded during run 191426. The leading photon has $E_T$=64.2 GeV and $\eta$=-0.34. The subleading photon has $E_T$=61.4 GeV and $\eta$=-0.61. The measured diphoton mass is 126.6 GeV. The $p_T$ and $p_{Tt}$ of the diphoton are 6.1 GeV and 5.4 GeV, respectively.

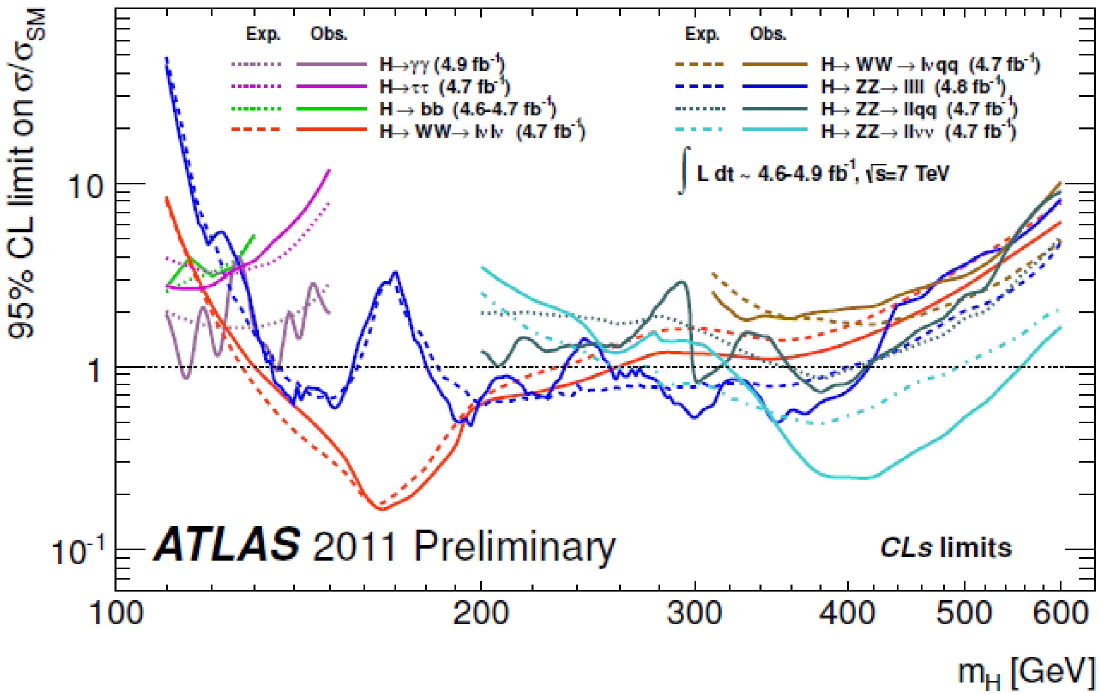
# $H \rightarrow \gamma\gamma$

- Analysis uses both converted and unconverted photons, and different categories are defined for different detector regions
- Further split in bins of diphoton pt component transverse to diphoton thrust (better resolution wrt “plain” pt)
  - In total, analysis uses 9 categories
- Background modeled by single exponential, signal as Gaussian+Crystal Ball
- Main uncertainties on signal yield: 11% from photon reconstruction and identification; 4% from pileup; 5% from photon isolation; +15%/-11% from signal cross section; 12% from calorimeter resolution; 6% from energy calibration
- Observed exclusion: 114-115GeV and 135-136GeV
- Most significant excess is 2.8σ@126GeV
  - 1.5σ once LEE is taken into account

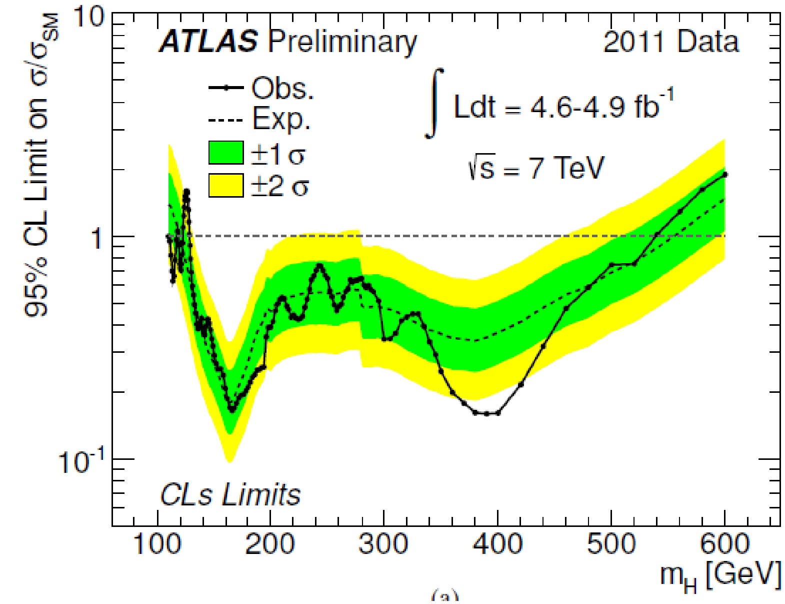


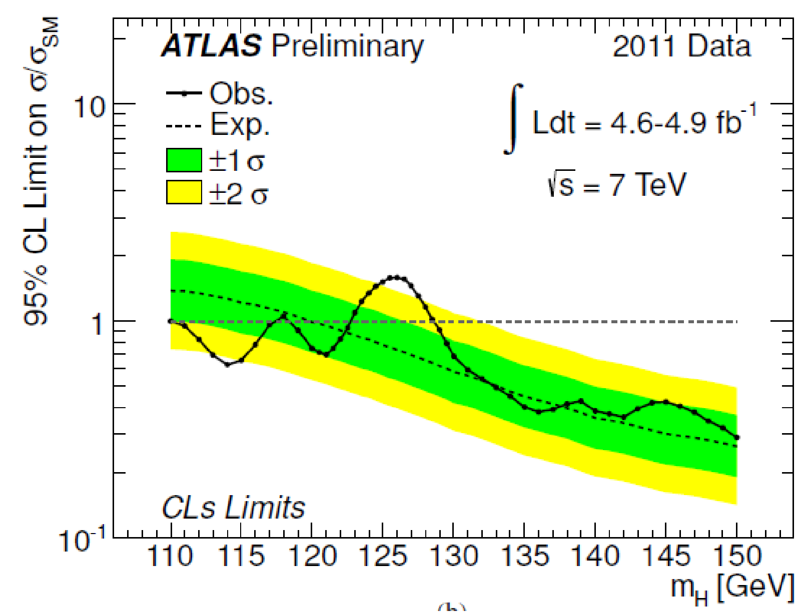



# ATLAS Higgs combination



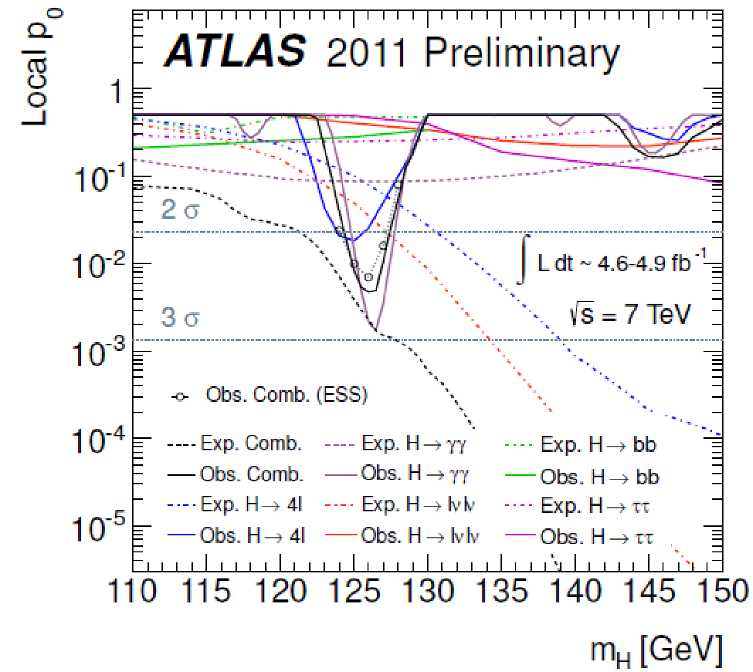

- Expected limits: 120-555GeV
- Observed 95% CL exclusion regions are
  - 110.0 GeV - 117.5 GeV
  - 118.5 GeV - 122.5 GeV
  - 129 GeV- 539 GeV

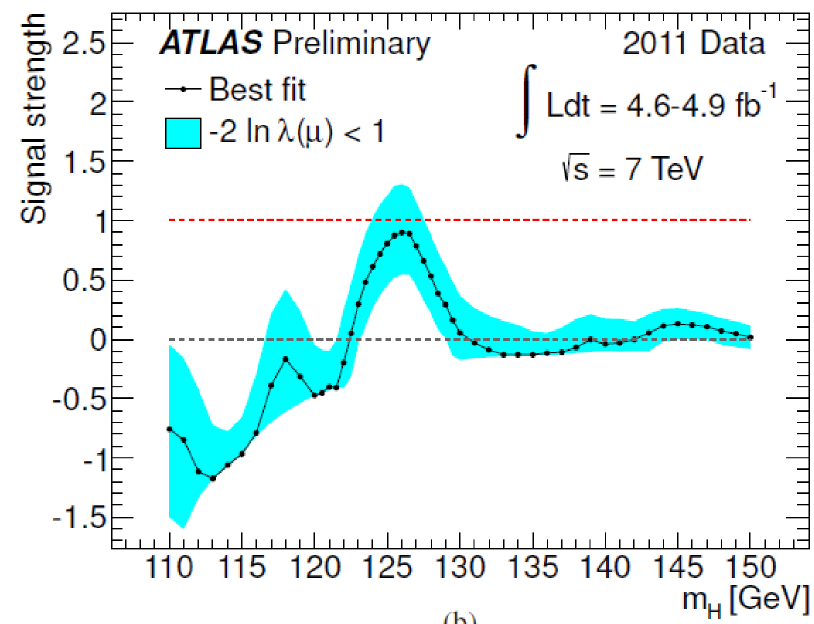


# ATLAS Higgs combination (2)

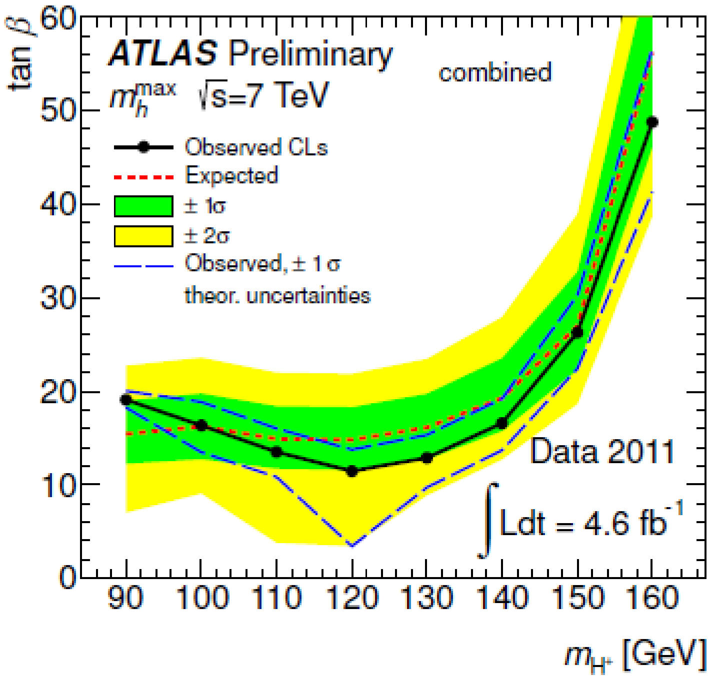
- An excess of events is observed in the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ(*) \rightarrow 4l$ channels @ ~126GeV
  - local significances of 2.8σ and 2.1σ respectively.
  - Expected sensitivities for SM H @ 126 GeV are 1.4σ for both channels.
- The local *ATLAS combined* significance is 2.5σ
  - expected significance for SM H @ 126 GeV is 2.9σ.
- How likely is such an excess to be observed (in the absence of a Higgs signal) in all the mass range under study?
  - ***preliminary*** estimate: ~30% from 100GeV to 600GeV; ~10% in the region not excluded @ 99%CL (from 110GeV to 146GeV)

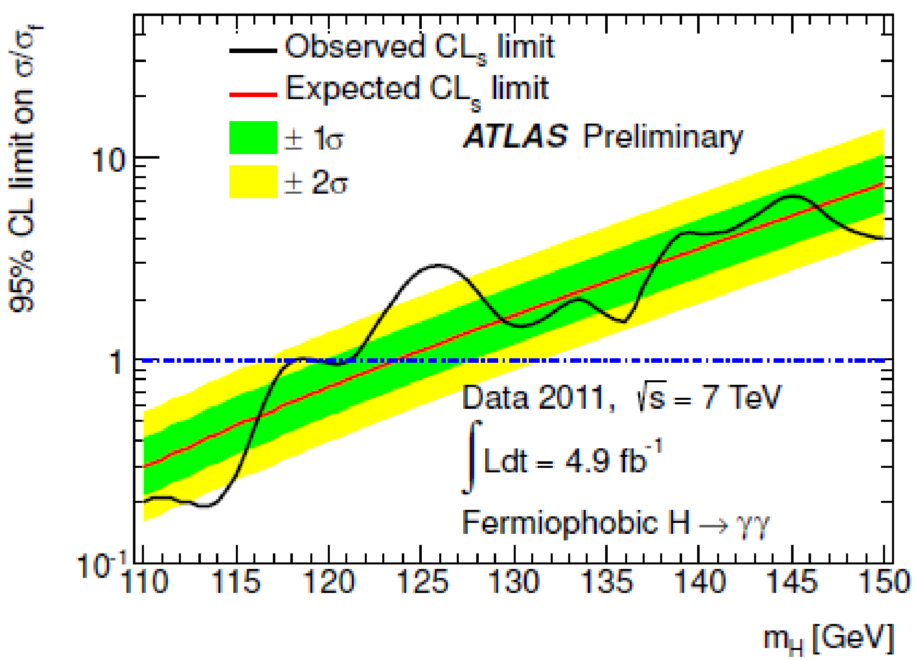


# Bonus: BSM H

- Also actively looking for non-SM Higgs bosons
  - Charged H ($t \rightarrow bH \rightarrow b\tau\nu$)
  - Fermiophobic H ($\rightarrow \gamma\gamma$)
  - ...



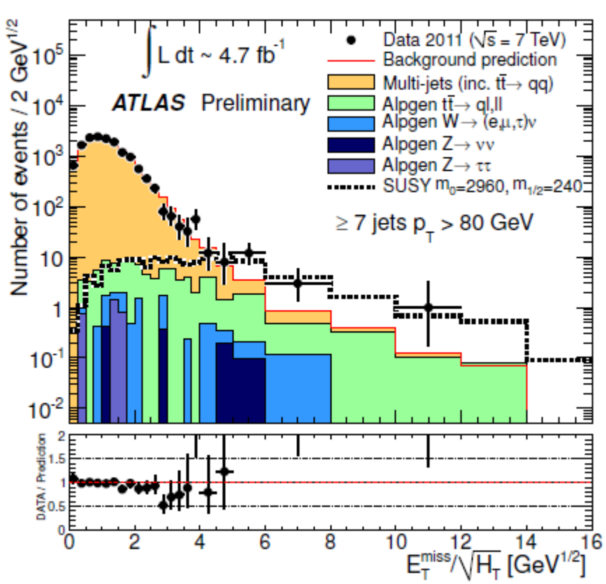



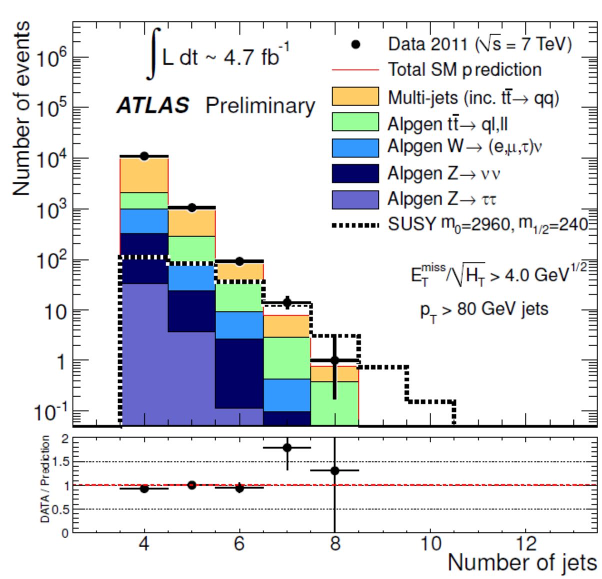
# New Physics searches

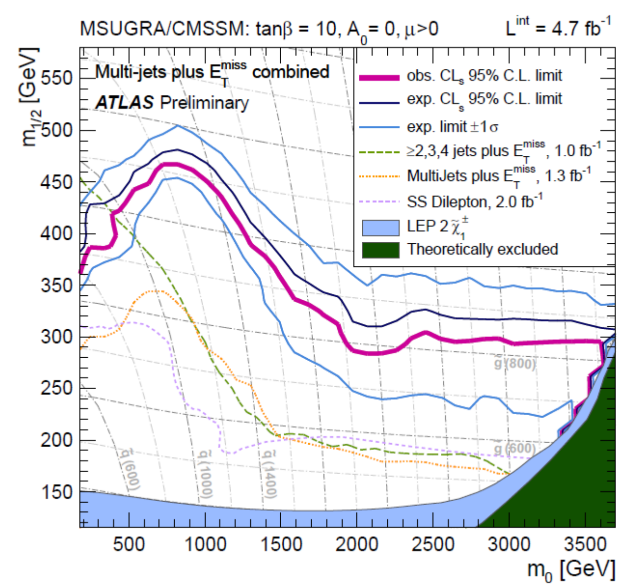
l+jet+Etmiss
in backup

# SUSY: inclusive searches

- Many NP models predict spectacular decay chains, whose last link could be non-interacting
  - Analysis looks for excess of events with high jet multiplicities and large (significant) missing transverse energy
- Main background is multijet production (QCD, ttbar, W/Z+jets)
  - non-leptonic: use templates extracted from data in events with lower multiplicity and/or lower Etmiss. Main systematics come from template transfers from lower to higher jet multiplicities (15%-25%)
  - leptonic: use MC, normalized in ad-hoc, signal-depleted, control regions. Main systematics come from Jet Energy Scale (6%)



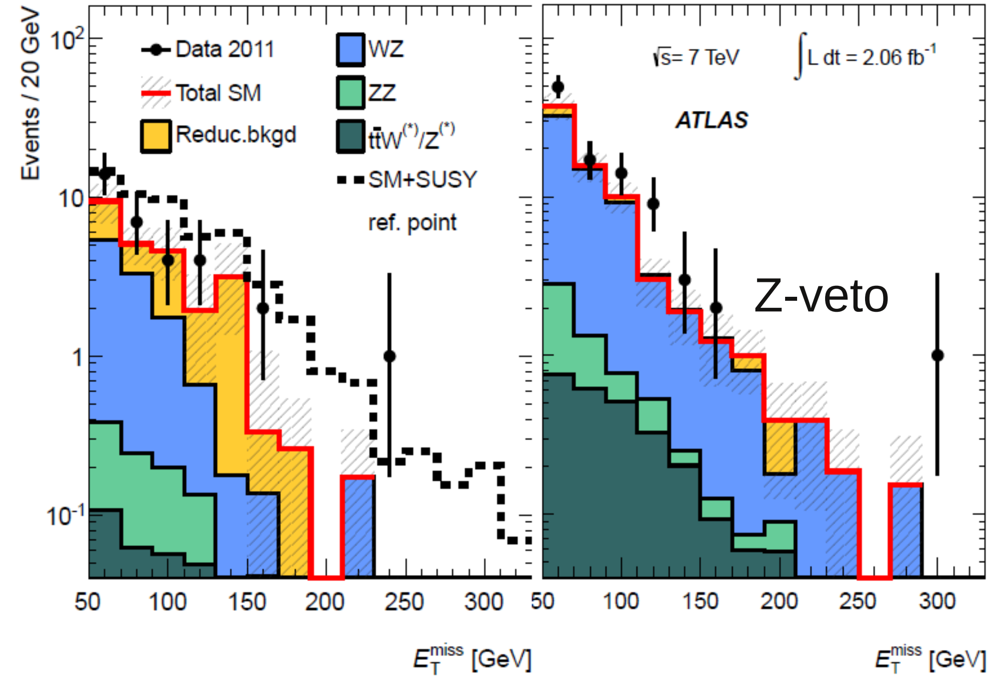



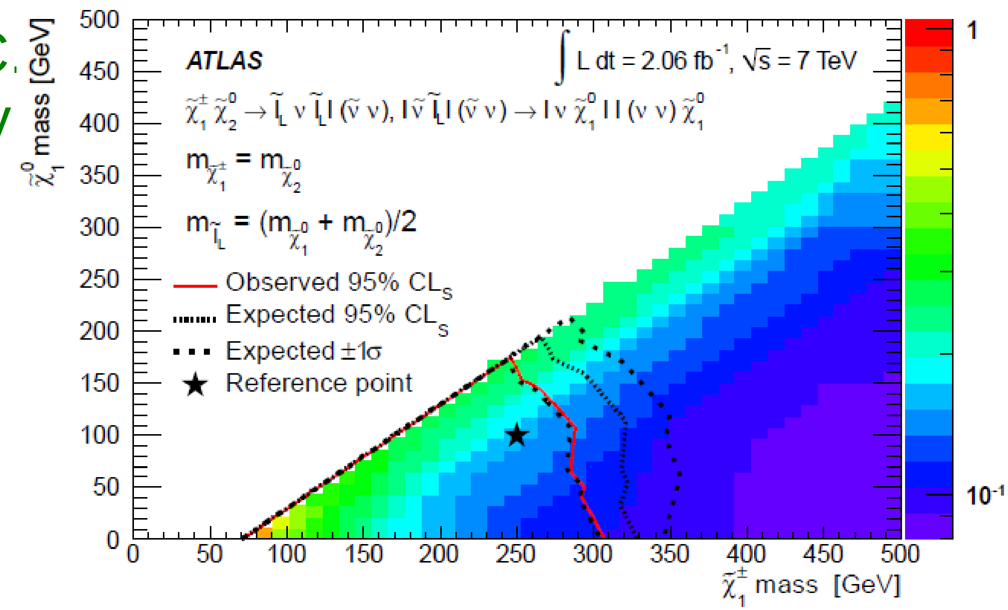



stop pair
in backup

# SUSY: 3l+Etmiss

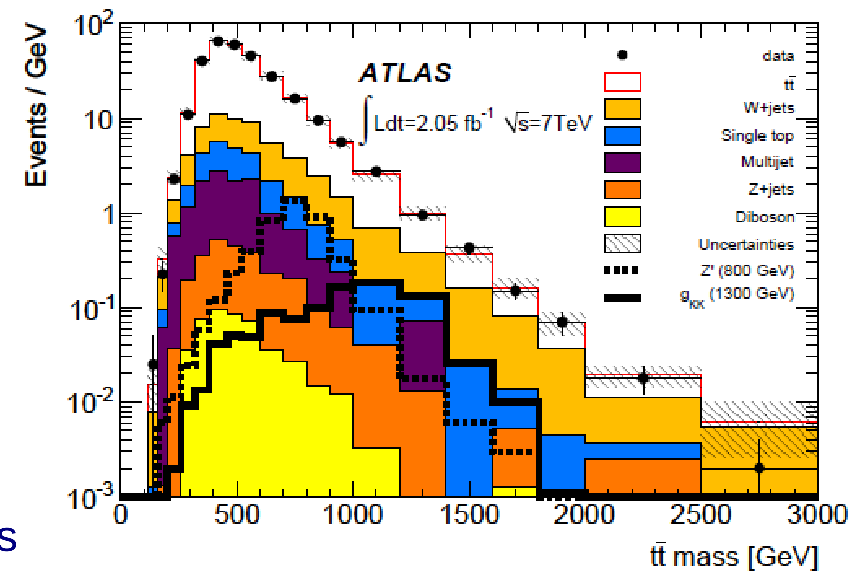
- Could signal leptonic decay of a gaugino pair
- Require three high-pt, isolated leptons, two of them same flavor opposite sign
  - Analysis with and without Z-veto
- Backgrounds
  - Irreducible: WZ(*), ZZ(*) and ttbar+W/Z(*) estimated from MC. Total unc. of 17%, dominated by PDFs
  - Reducible: top and Z+jets using partially data-driven method. Total unc. of 29%
- Signal cross section unc. is 10-15%

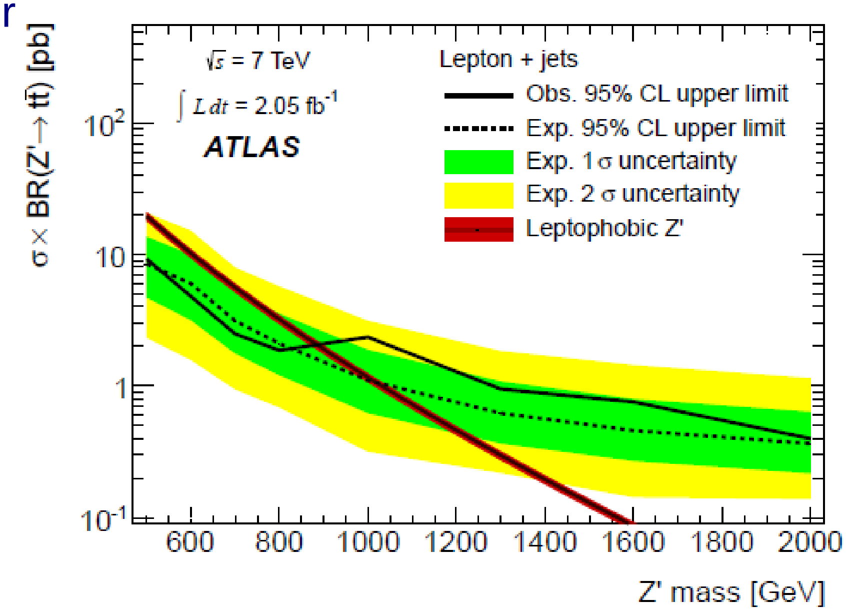


# BSM: ttbar resonances

- Look for ttbar resonances in events where only one or both of the W bosons decays leptonically
  - Signature is one (two) high-pt, isolated leptons, large Etmiss, 3-4 high-pt jets (at least one b-tagged).
- Dominant backgrounds estimates:
  - MC-based shapes (ttbar and single top)
  - MC shapes with data-driven corrections (W+jets)
  - data control regions + MC extrapolation to signal region (Z+jets)
  - Templates from data (multijet)
- Main uncertainties on bg normalization are 76% on multijets and W+jet for the dilepton analysis and 50% on multijets for the lepton+jets analysis
- Other systematics on yields for lepton+jets channel include b-tagging (13% on bg, 17% on signal), jet energy scale (15% on bg, 4% on Z' signal)
- Uncertainties in the dilepton channel dominated by modeling of ISR and FSR (1%-5%), JES (2.5%-3%), PDFs (3.7%-0.6%)

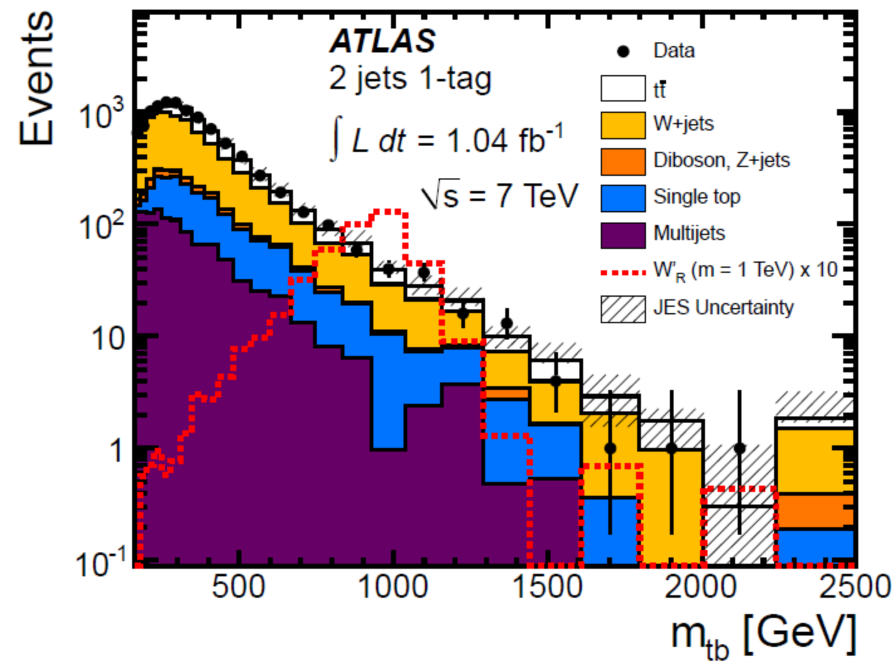


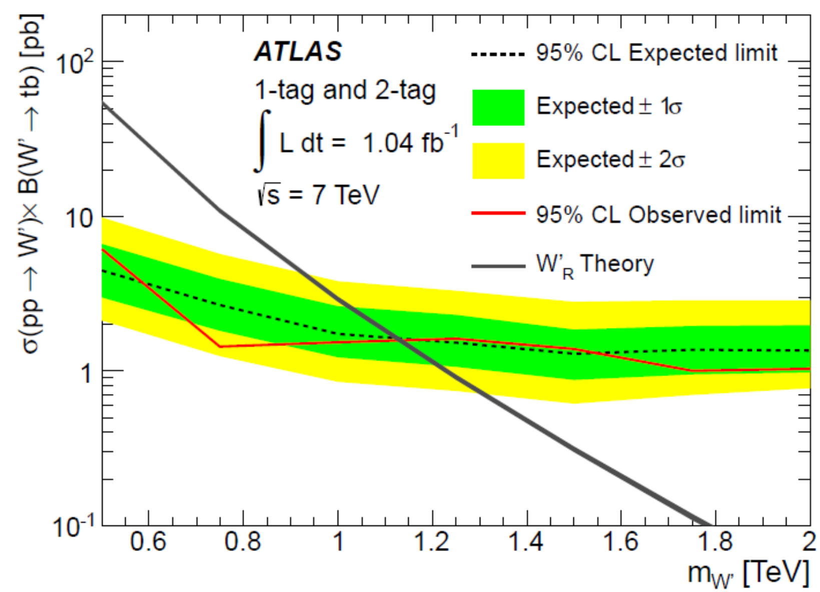



l*, q*, Z'
in backup

# BSM: $W' \to tb \to l\nu bb$

- Competitive if leptonic decays suppressed
- Signature is one high-pt, isolated lepton, Etmiss, two jets (one or both b-tagged)
- Background estimates
  - W+jets: shapes from MC, flavor composition and overall normalization from data in signal free control region
  - Multijet: shapes from data in CR, normalization from Etmiss spectrum in data (unc. on yield of 50%-100%)
  - ttbar, single top, Z+jet and diboson: shape and normalization from MC (unc. on yield of 10% for top, 5% for diboson, 60% for Z+jet)



# Conclusions

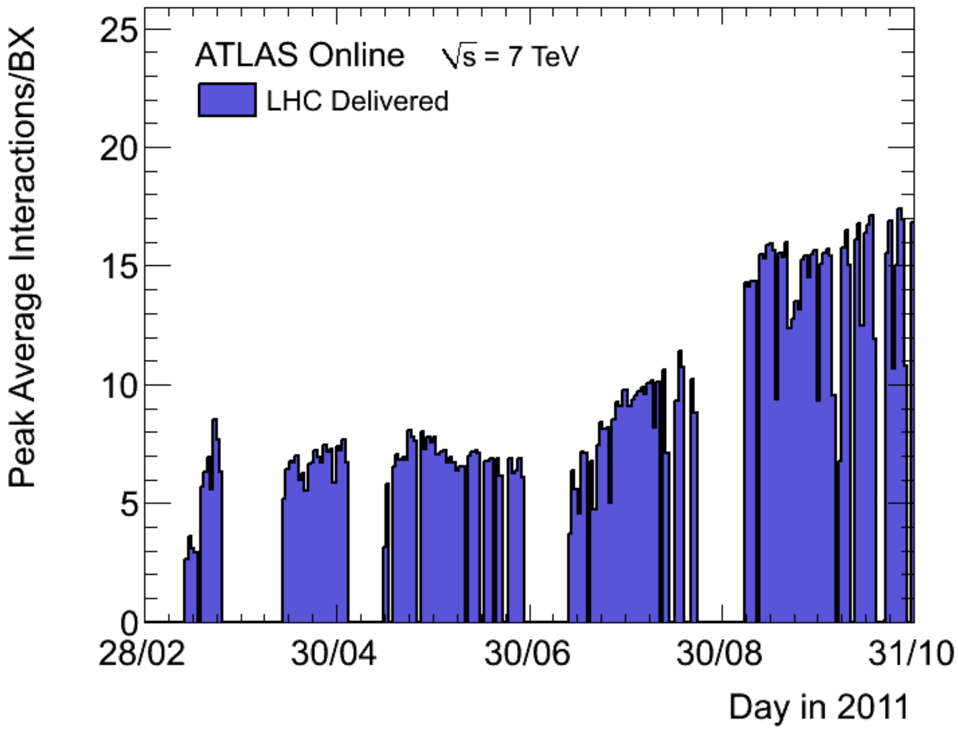
- LHC operation @ 7TeV provided a wealth of information
  - Being digested at a steady pace
  - we are producing many interesting results
- Standard Model physics is the very first benchmark
  - At an unexplored CM energy
- Searches for new physics ongoing
  - Limited statistics forces analyses to be as inclusive as possible
    - Model independent!
  - Exclusion of some models already possible, in regions of phase space not yet covered by Tevatron
- Update of analyses, including 2012 data @ 8TeV is ongoing
  - … stay tuned!
- More from ATLAS today:
  - 15:20 “**ATLAS measurements of soft particle production and diffraction**”, S. Todorova
  - 17:10 “**Probing QCD with jets, photons and weak bosons at the LHC with ATLAS**”, B. Cooper

# Further reading

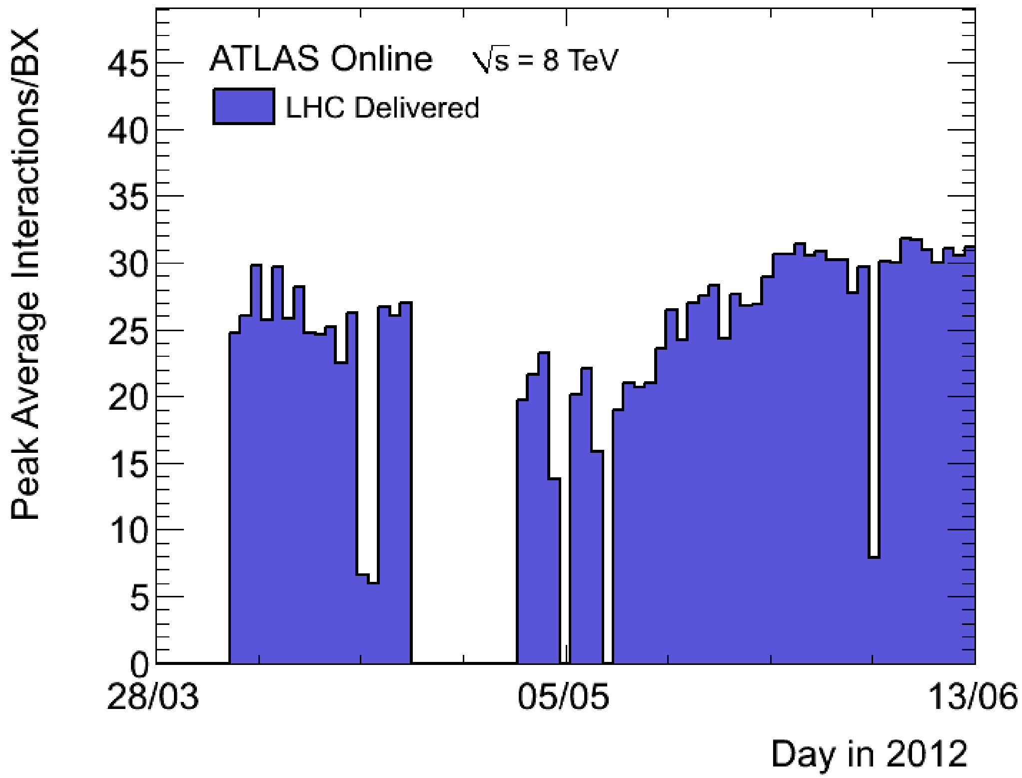
- Standard Model:
  - arXiv:1205.2531, arXiv:1203.6232, arXiv:1203.4051, arXiv:1203.4606, arXiv:1205.2067, arXiv:1205.5764, ATLAS-CONF-2012-056
- Higgs
  - ATLAS-CONF-2012-018, ATLAS-CONF-2012-016, ATLAS-CONF-2012-017, ATLAS-CONF-2011-162, ATLAS-CONF-2012-012, ATLAS-CONF-2012-014, ATLAS-CONF-2012-015, ATLAS-CONF-2011-161, ATLAS-CONF-2012-019, ATLAS-CONF-2012-013, ATLAS-CONF-2012-011,
- New Physics:
  - ATLAS-CONF-2012-008, ATLAS-CONF-2012-038, ATLAS-CONF-2012-007, ATLAS-CONF-2012-037, ATLAS-CONF-2012-041, arXiv:1205.1016, arXiv:1205.5371, arXiv:1204.6736, arXiv:1204.5638

# *Backup*

# Pileup



ATLAS Online $\sqrt{s}$ = 7 TeV
LHC Delivered
Peak Average Interactions/BX
Day in 2011
28/02
30/04
30/06
30/08
31/10

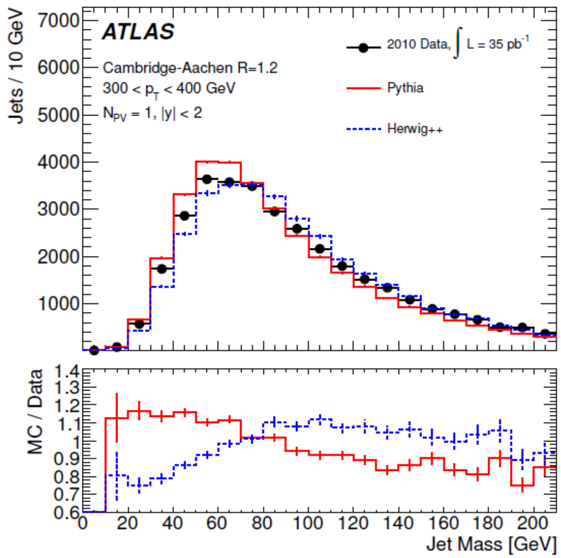



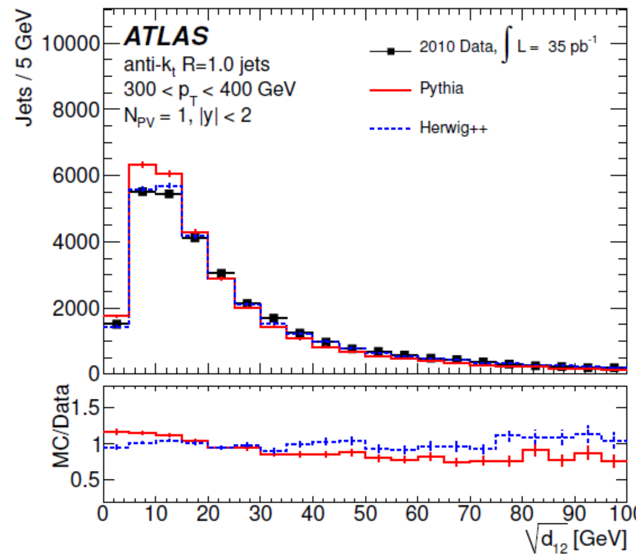
ATLAS Online $\sqrt{s}$ = 8 TeV
LHC Delivered
Peak Average Interactions/BX
Day in 2012
28/03
05/05
13/06

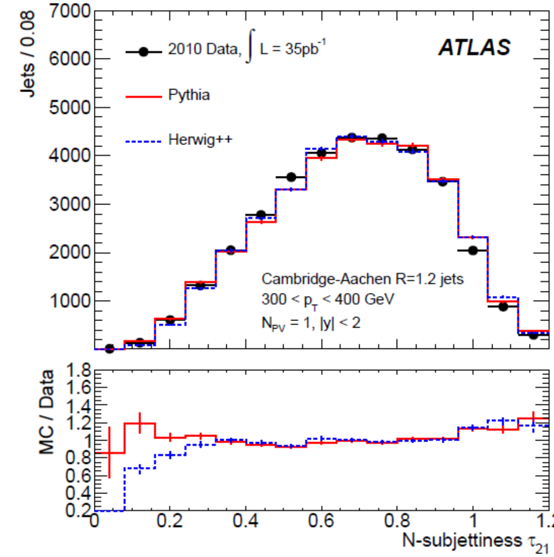
# *Standard Model*

- Investigations and measurements in the realm of “old” physics are of paramount importance for the understanding of any new physics signal
- Precision measurements may actually allow us to catch a a glimpse of completely new phenomena
  - unexpected deviations
- A few highlights of our Standard Model programme
  - Jet mass and substructure
    - How well does parton-showering reproduce internal substructure of jets? Would we be able to resolve the decay of a (new) boosted heavy particle?
  - W/Z production cross sections
    - Direct insight on PDFs
  - Di-boson physics
    - aTGCs probe for BSM physics
  - Top physics
    - Wt, $R_t$

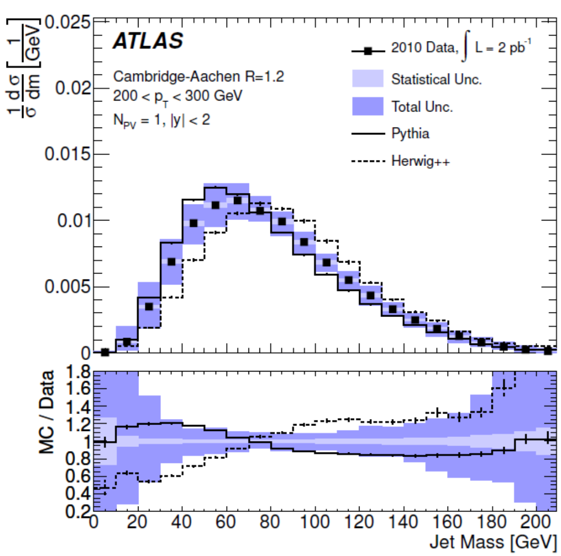
# Jet substructure

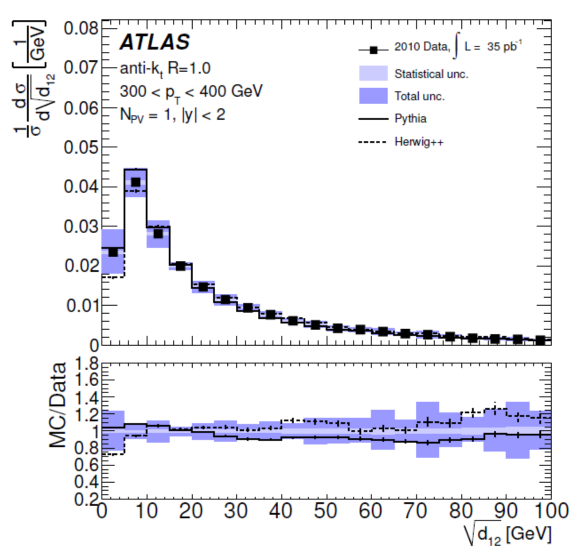


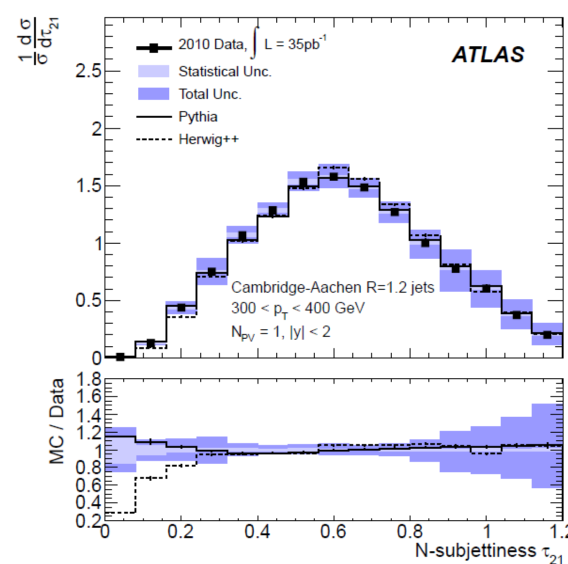




**Detector Level**    **After unfolding detector effects and acceptance**

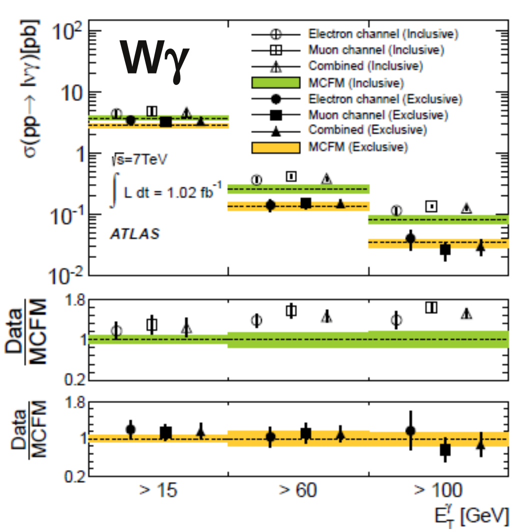


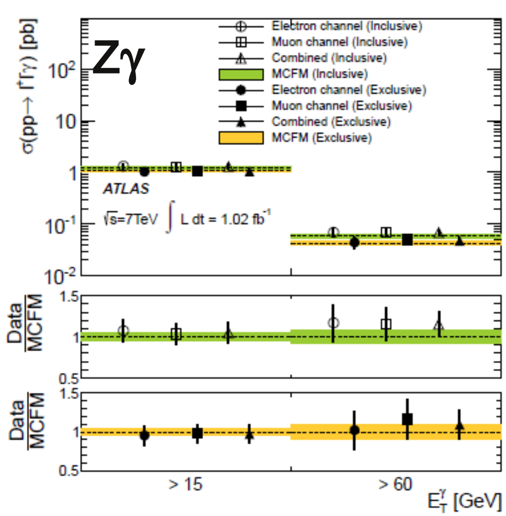



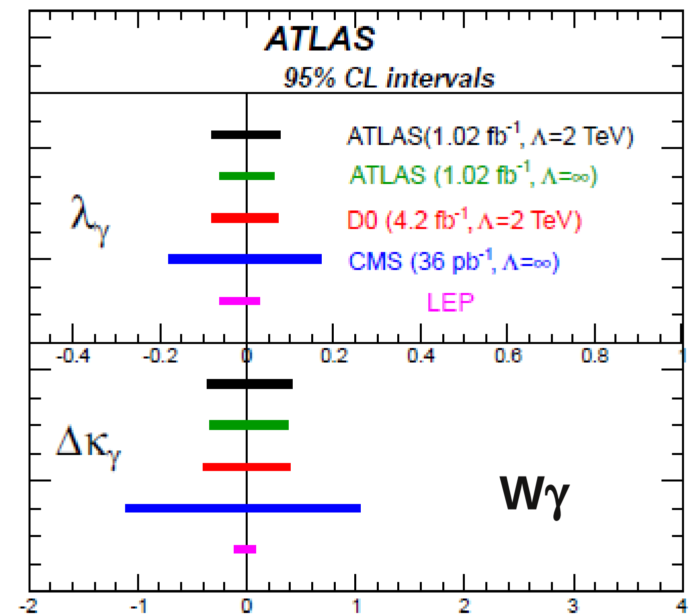



# Dibosons: $W\gamma \rightarrow l\nu\gamma$, $Z\gamma \rightarrow ll\gamma$

- Select high-pT, isolated leptons and photons, apply (transverse) mass cuts/vetoes
  - main background from W/Z+jets, with photons from jet fragmentation passing the selection criteria. For Wγ, γ+jets are also important, due to high-pT leptons arising from heavy-flavor decays
    - Both estimated using data driven methods
- Systematics on selection efficiencies between 8.3% and 12.5%, depending on the energy of the photon, dominated by photon identification efficiency and Jet energy scale
- Systematics on acceptance dominated by PDFs (<1%) and renormalization and factorization scale (1%-3.5%)
- Use results to constrain aTGCs



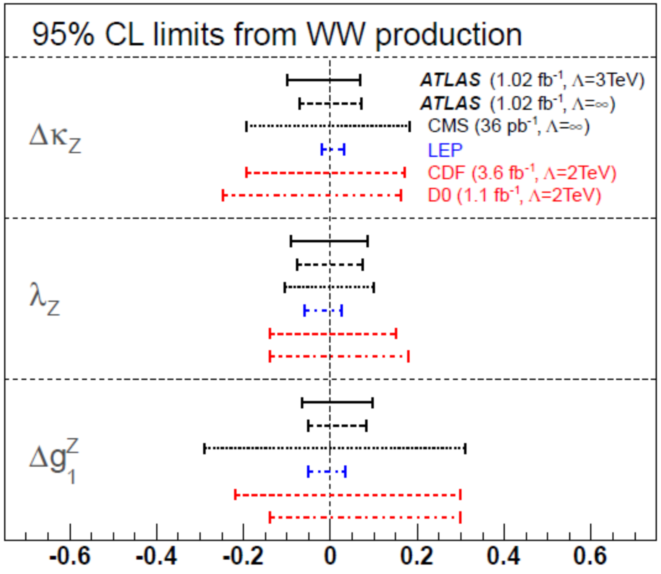



# Dibosons: $WW \rightarrow l\nu l\nu$

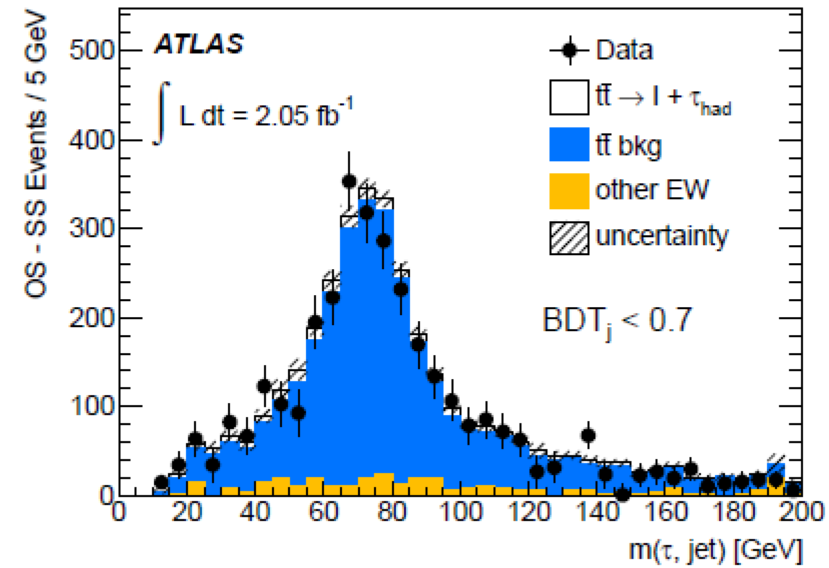
- Select high-pT leptons, large missing transverse energy, apply transverse mass cut, veto b-jets, veto Z boson
  - Main backgrounds from Drell-Yan dileptons with misreconstructed jets faking large missing Et, and top events
    - Bg is estimated using MC predictions, constrained using data in signal-free (or signal-depleted) control regions
- Uncertainties dominated by jet veto acceptance (~5%) and lepton efficiency/acceptance (2%-4%)

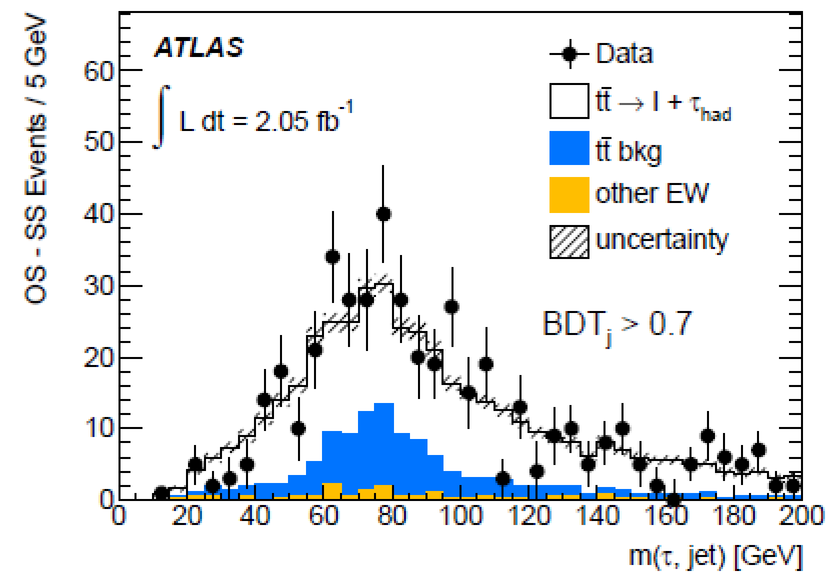
$$\sigma(pp \rightarrow WW) =$$
$$54.4 \pm 4.0\,(\text{stat.}) \pm 3.9\,(\text{syst.}) \pm 2.0\,(\text{lumi.})\ \text{pb},$$



# ttbar → $l+\tau_{had}+X$

- Interesting probe of non-standard decay modes ($t \rightarrow bH^{+} \rightarrow b\tau\nu$). Challenge is good control on $\tau$ identification performance
- Use MV techniques to identify $\tau$, and to discriminate between true and fake $\tau$ (from e and jets)
- Opposite/same charge requirement on l and $\tau$ allow to suppress most the charge-symmetric backgrounds (fake $\tau$ from gluons, multijet, bbar)
  - Remaining light-quark $\tau$ fakes estimated from data using template fit on MV discriminant. Shape from data in signal-depleted control regions
- Main systematics are b-tagging (7.5%-9%) and modeling of ISR/FSR (3.5%-4.8%)

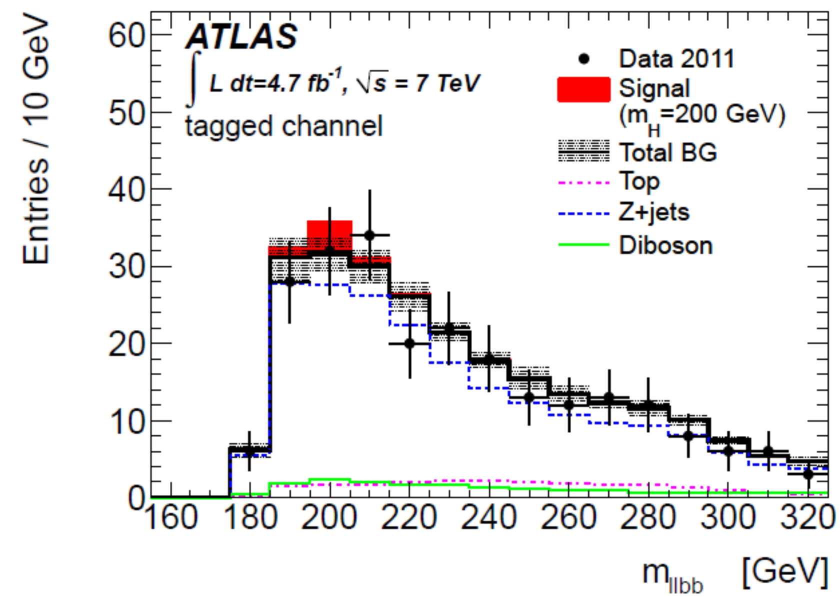


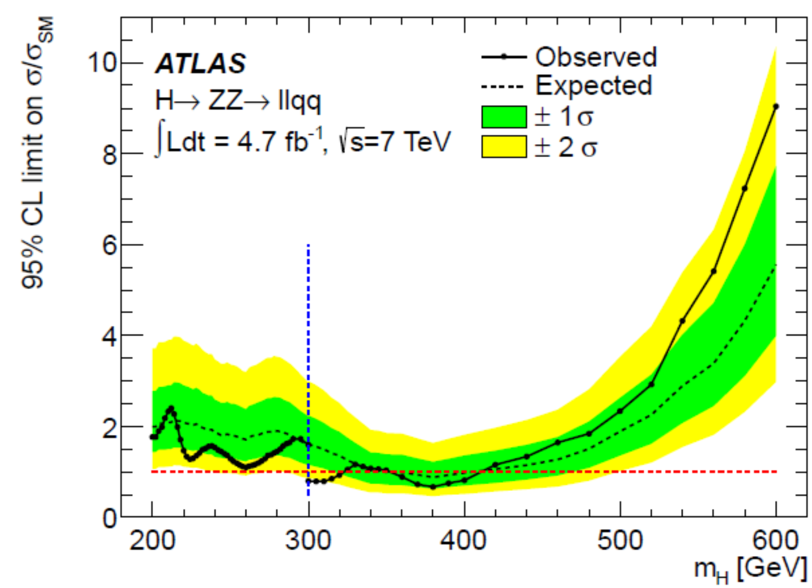




$$\sigma_{t\bar{t}} = 186 \pm 13\ (\text{stat.}) \pm 20\ (\text{syst.}) \pm 7\ (\text{lumi.})\quad \text{pb}$$

# $H \rightarrow ZZ \rightarrow llqq$

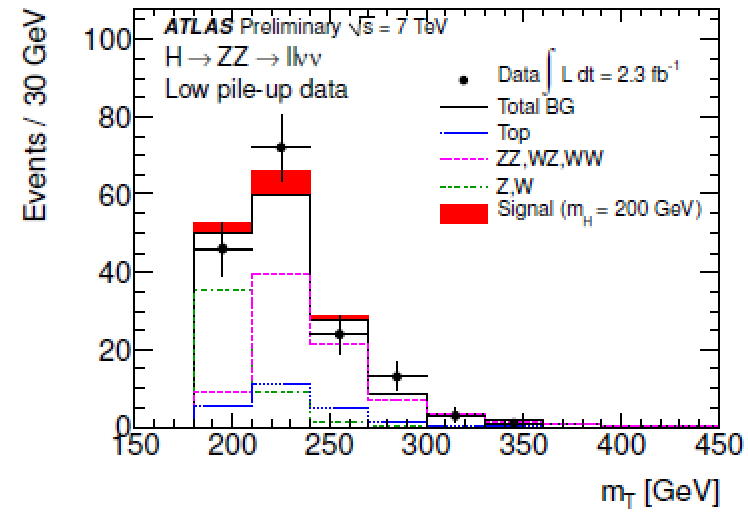
- Look for two leptons from Z, two well separated jets from Z, low Etmiss
- ZZ → llbb more likely than Z+jets → llbb, i.e. can use b-tagging to enhance signal contribution
- As in llνν, use $m_H$-dependent cut on angle between leptons to improve signal sensitivity
- Main background is Z+jets and ttbar (for the b-tagged sample)
  - Shape from MC, normalized using sidebands in $m_Z$ spectrum
- Theory systematics on signal normalization are 15%-20% for ggF and 3-9% for VBF. Additional 3%-12% due to signal acceptance
- Z+jets uncertainty 2.1%-5.9%; dibosons 11%; QCD multijets 50%
- b-tagging: 14%; jet scale 4%
- Expected exclusion: 351-404GeV
  - **Observed: 300-322GeV and 353-410GeV**



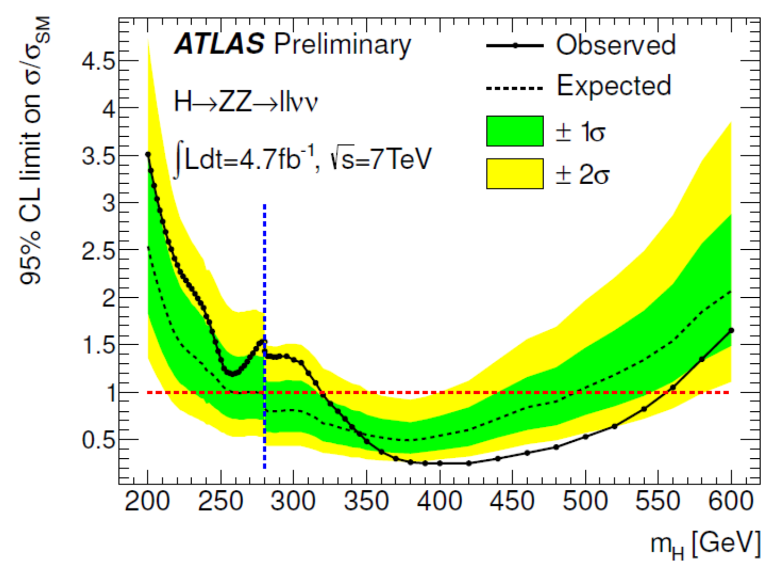



# $H \rightarrow ZZ \rightarrow ll\nu\nu$

- Useful in the region 200-600GeV, thanks to large boost resulting in large Etmiss and lepton pt
  - Most sensitive channel above 300GeV
- Cuts on jets are used to suppress ttbar background and improve Etmiss quality
- $m_H$-dependent cut on angle between leptons to improve signal sensitivity
- Background estimated using MC, validated in signal-free control regions (e.g. e+μ events)
- Normalization uncertainties on signal and diboson bg from theory
  - ~12% ggF, 4% VBF, 11% diboson
- Uncertainties for other processes from data
  - Z 2.5%, top 9%, W 100%, QCD multijet 50%
- $m_H$-dependent acceptance uncertainty of 8.4% to 3.4%
- Expected exclusion: 260-490GeV
  - **Observed: 320-560GeV**



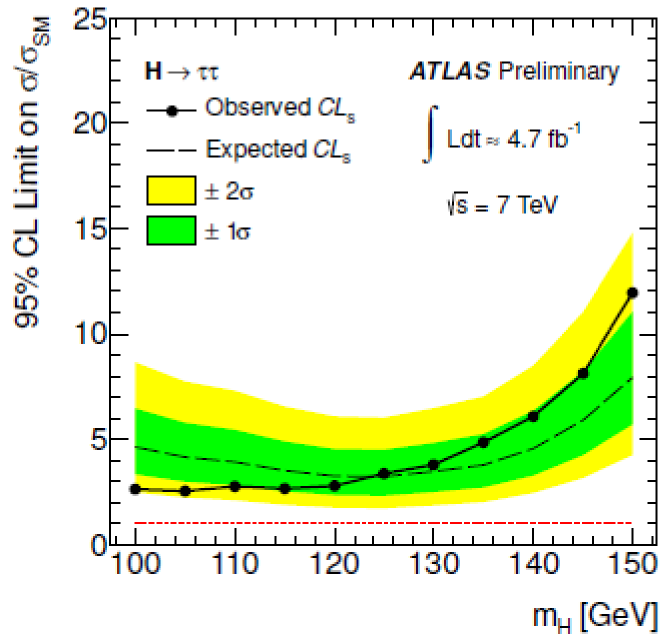

$$m_T^2 \equiv \left[\sqrt{m_Z^2 + |\vec{p}_T^{\,\ell\ell}|^2} + \sqrt{m_Z^2 + |\vec{p}_T^{\,\rm miss}|^2}\right]^2 - \left[\vec{p}_T^{\,\ell\ell} + \vec{p}_T^{\,\rm miss}\right]^2$$



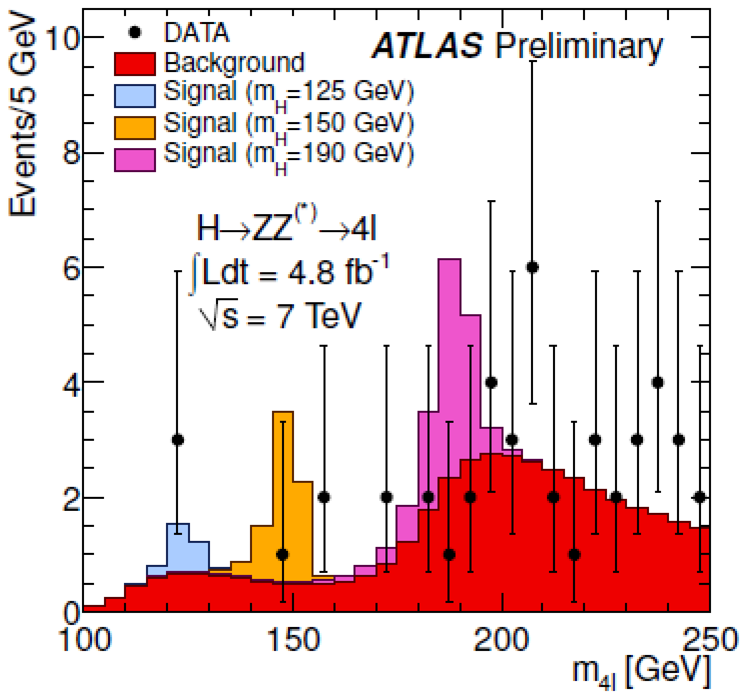
# $H \rightarrow \tau\tau$

- Complementary to other low-mass searches
- Sensitivity enhanced by requiring additional jets, i.e. boost of the H, i.e. larger Etmiss from neutrinos
- Analysis performed in fully leptonic, semi-leptonic and fully hadronic channels
- Main background is $Z \rightarrow \tau\tau$, modeled from data by embedding simulated $\tau$ in real $Z \rightarrow \mu\mu$ events and normalized in regions with low Etmiss.
  - resulting uncertainty is 6%-40%

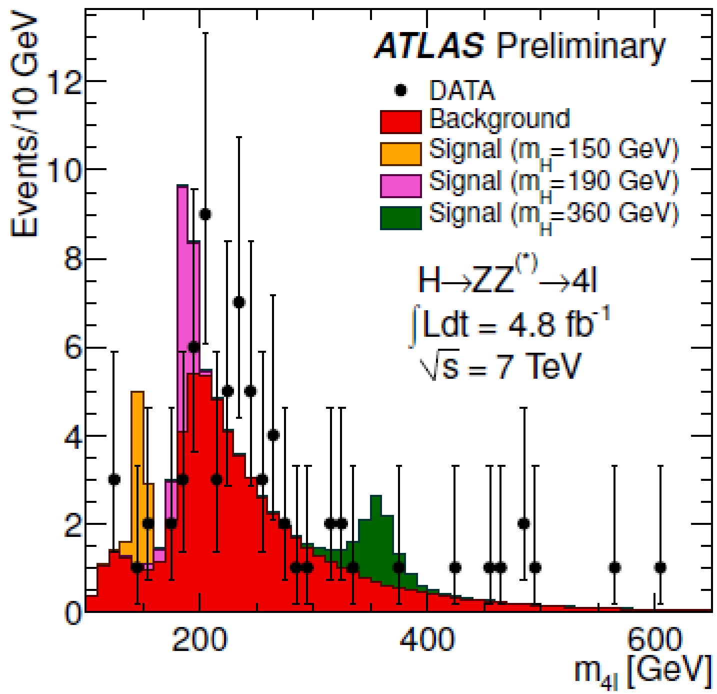
- Additional contribution from fake leptons, estimated from data using non-isolated leptons
- Theory uncertainties on signal are 1% for ggF and 8%-25% for VBF; 4%-5% is assumed for single- and di-boson production, with a 24% relative added per additional jet
- Detector uncertainties in the range 2%-5%



# H4l, zoom



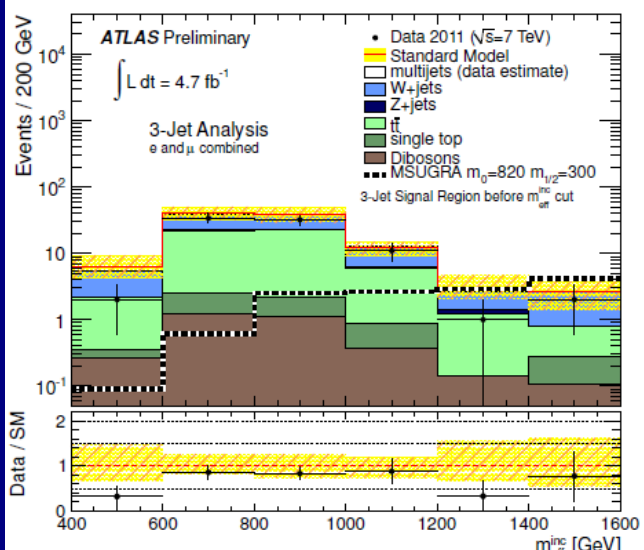
DATA
Background
Signal (m_H=125 GeV)
Signal (m_H=150 GeV)
Signal (m_H=190 GeV)
ATLAS Preliminary
H→ZZ(*)→4l
∫Ldt = 4.8 fb-1
√s = 7 TeV
Events/5 GeV
m4l [GeV]

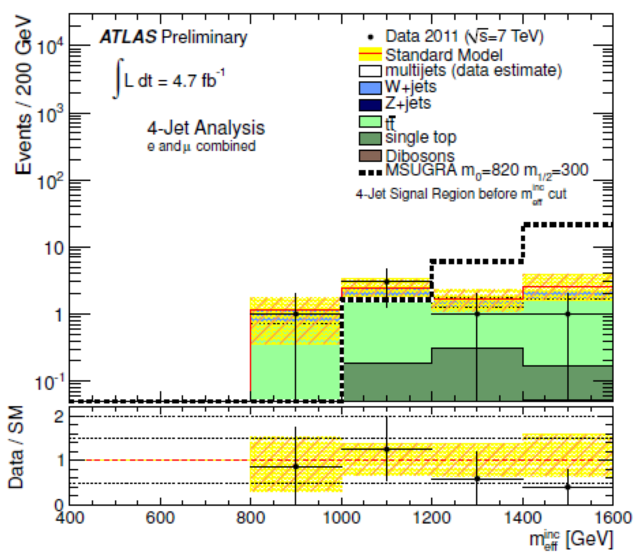



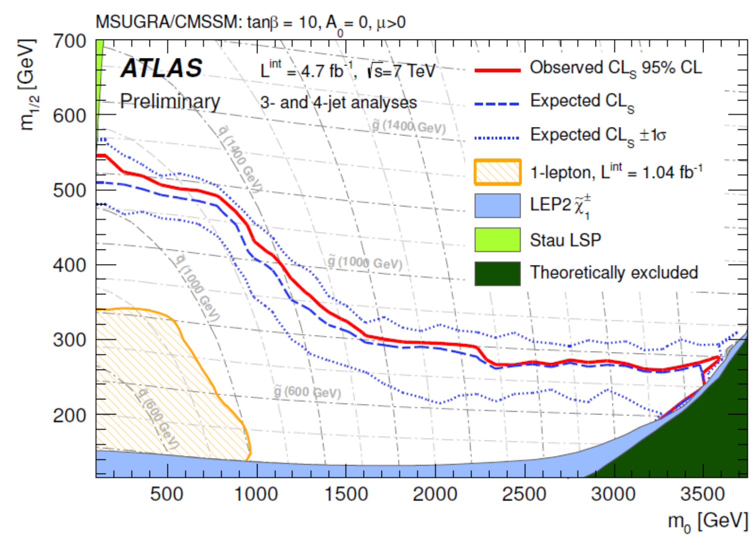
ATLAS Preliminary
DATA
Background
Signal (m_H=150 GeV)
Signal (m_H=190 GeV)
Signal (m_H=360 GeV)
H→ZZ(*)→4l
∫Ldt = 4.8 fb-1
√s = 7 TeV
Events/10 GeV
m4l [GeV]

# SUSY (2)

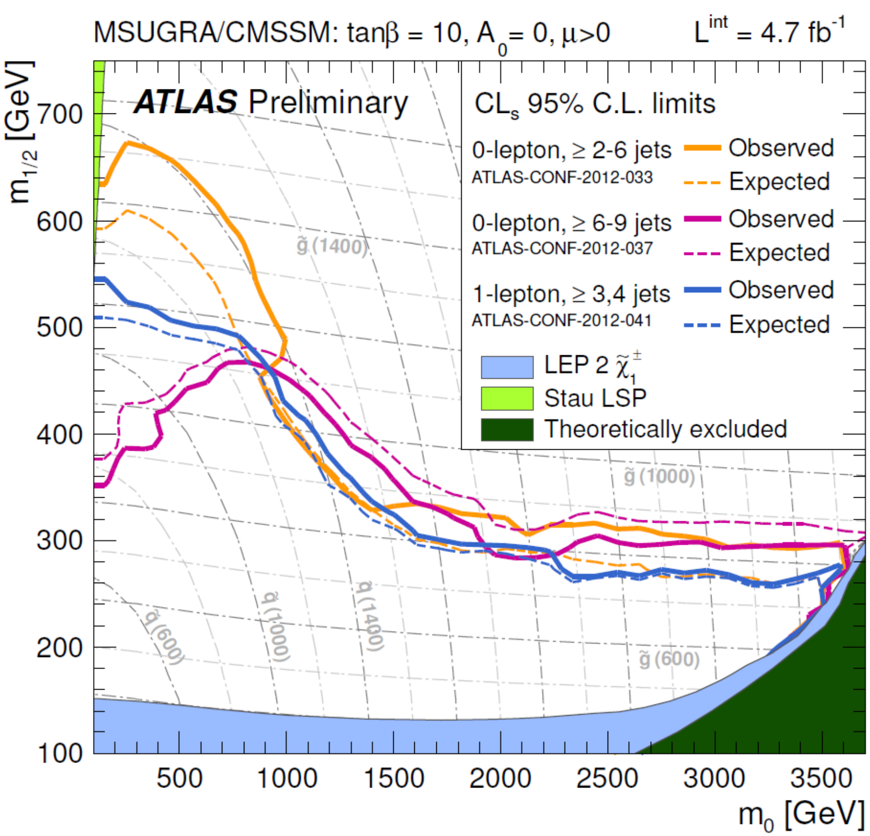
- Another possibility is to look for jets, *leptons* and missing Et
  - Lepton pT can be as low as 6GeV (requiring harder jets, though)
- Main backgrounds are ttbar (semi or fully-leptonic) and leptonic W+jets
  - Estimated using MC normalized to data in control regions with lower Etmiss, and extrapolating to signal region using simulation
  - Multijet background estimated from data using matrix method



# SUSY (3)



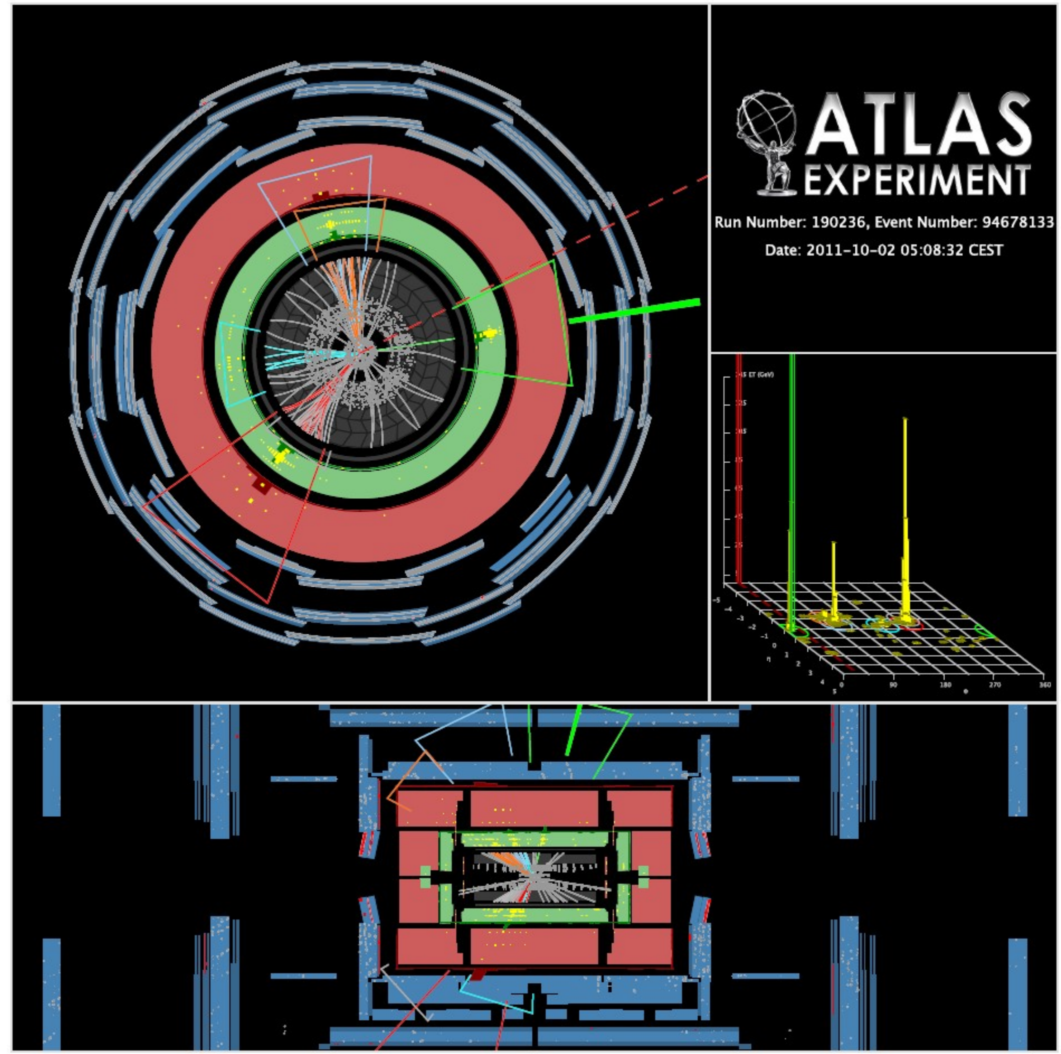
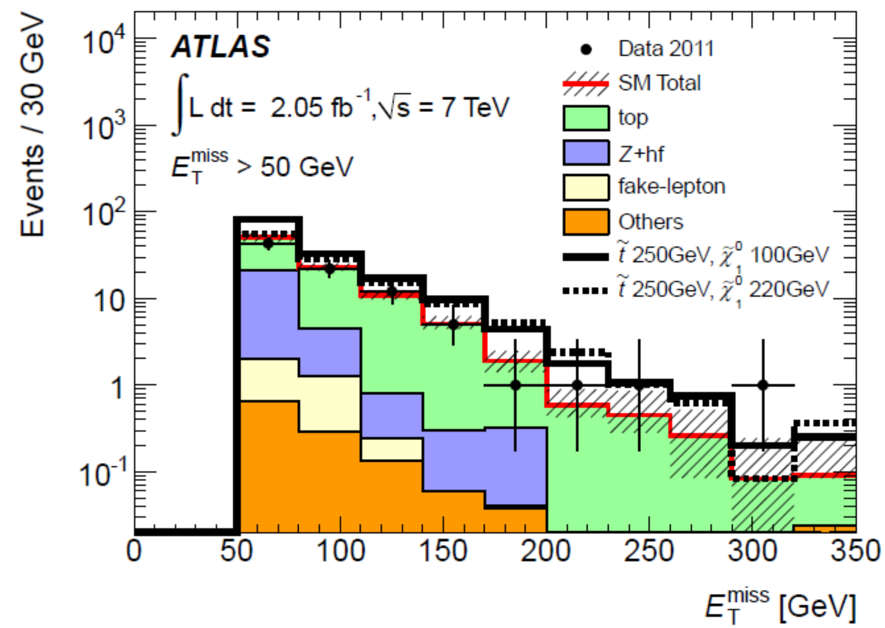
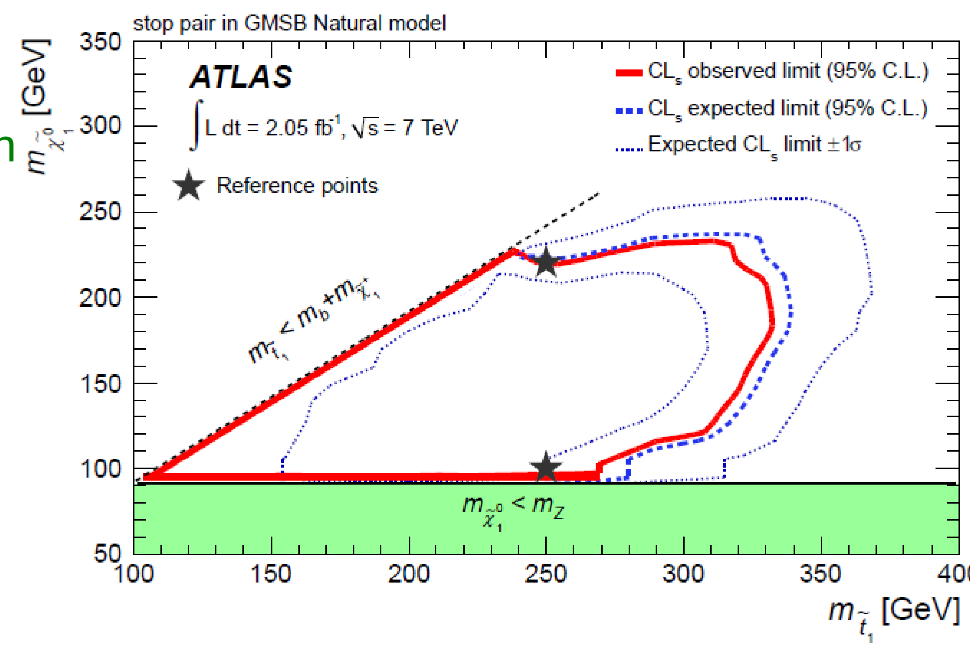




Figure 9: Event display of the electron event with the highest inclusive effective mass, passing the 4-jet selection. The $p_T$ of the four leading jets are: 690, 254, 117 and 84 GeV. There is also a fifth jet with $p_T$= 36 GeV. The electron $p_T$ is 265 GeV and $E_T^{miss}$= 381 GeV. The inclusive effective mass is 1827 GeV.

# SUSY: stop pair

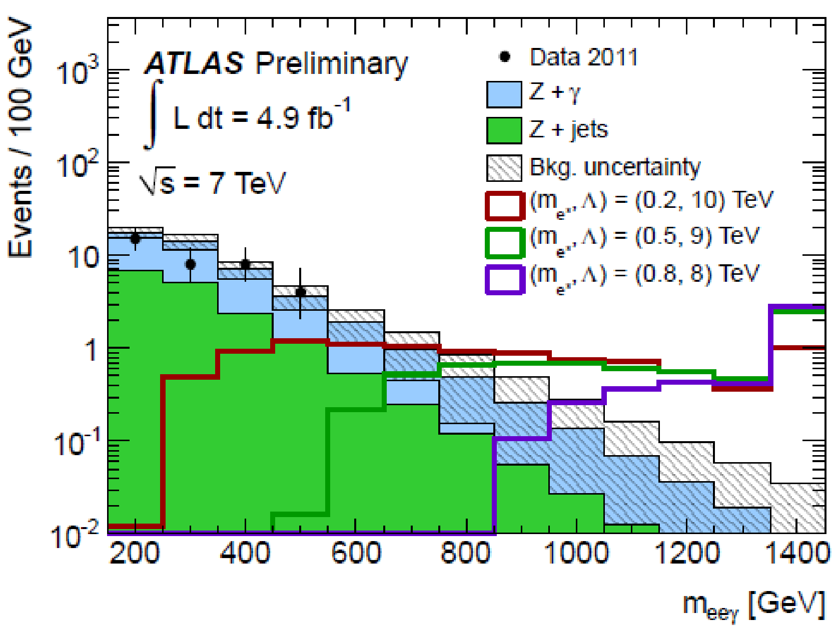
- Look for two leptons from Z decay, Etmiss, jets (at least one b-tagged)
  - In GMSB models with gravitino as LSP and neutralino as NLSP, this would signal stop pair production, each decaying in b+chargino or t+neutralino
- Main backgrounds:
  - Top: use signal-free control regions in data, extrapolate to signal region using MC. Unc. are 11%-13% from MC shapes and ~4% experimental (b-tagging, JES, lepton ID)
  - Z+heavy flavor: estimate from MC, validated in low Etmiss region in data. Unc. from production cross section 55% plus 24% relative per additional jet. 25%-35% experimental uncertainty (b-tagging, JES, lepton ID)
  - Data-driven estimate of W+jets and multijet. Unc. 50%-60%
  - MC estimate for diboson, Zttbar, Wttbar and ttbar+bbar . Unc. 100%

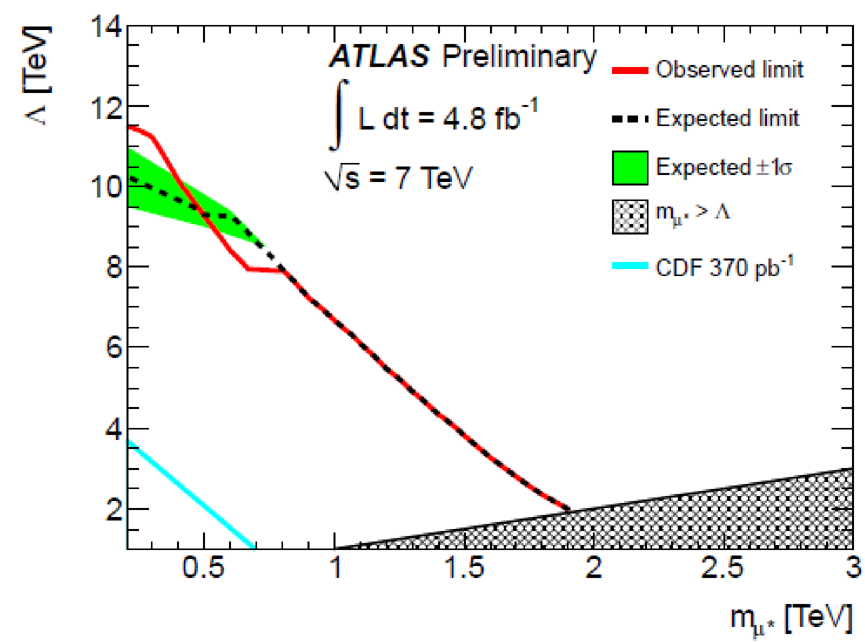


# BSM: excited leptons

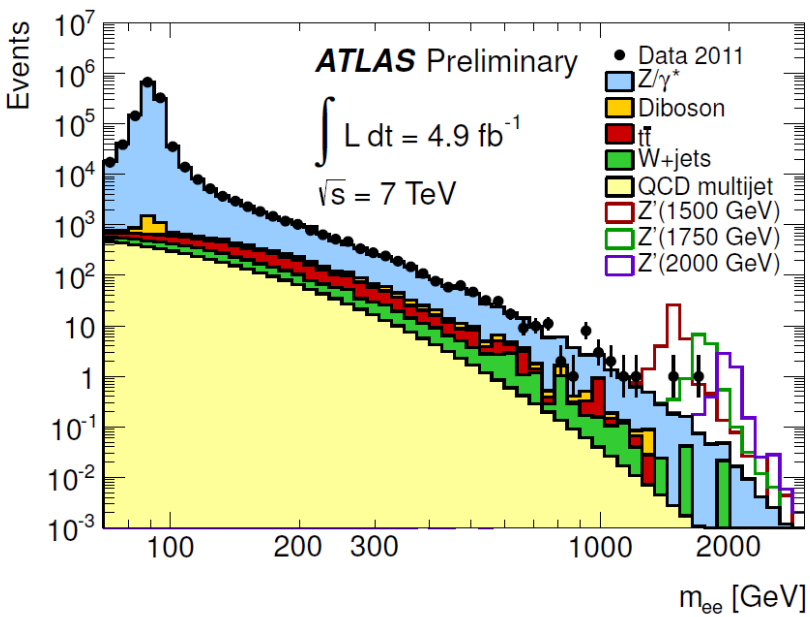
- Look for the decay l* → lγ in processes qq → l*l* or qq → ll*
  - Signature is llγ, all high energetic, well isolated/separated
- Dominant backgrounds are DY (Z+γ) and Z+jets, with one jet misidentified as a photon
  - Estimates use MC, normalized to data in control regions ($m_{ll}$<110GeV)
- Main observable is the mass of the llγ system

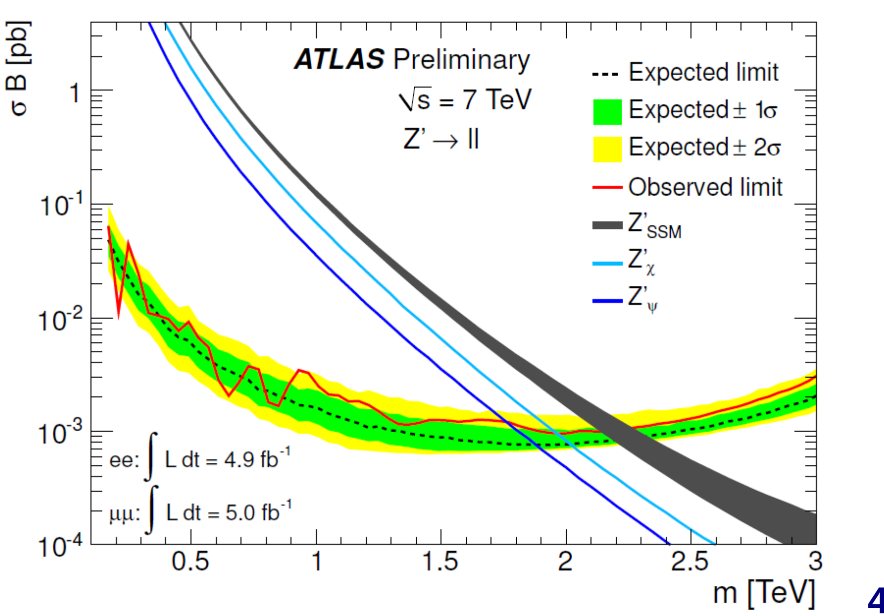


# BSM: dilepton

- Clean signal
  - Look for high-mass resonances decaying in lepton pairs
- Background comes from DY processes and leptons from heavy quark jets, as well as QCD jets being misidentified as electrons
  - The latter is estimated using templates from data in signal-free regions (reversing lepton ID cuts)
- Theory uncertainties on bg dominated by PDFs, $\alpha_s$ and scale variations (20% @ 2TeV)
- Experimental uncertainties are of the order of 6%



# BSM: dilepton

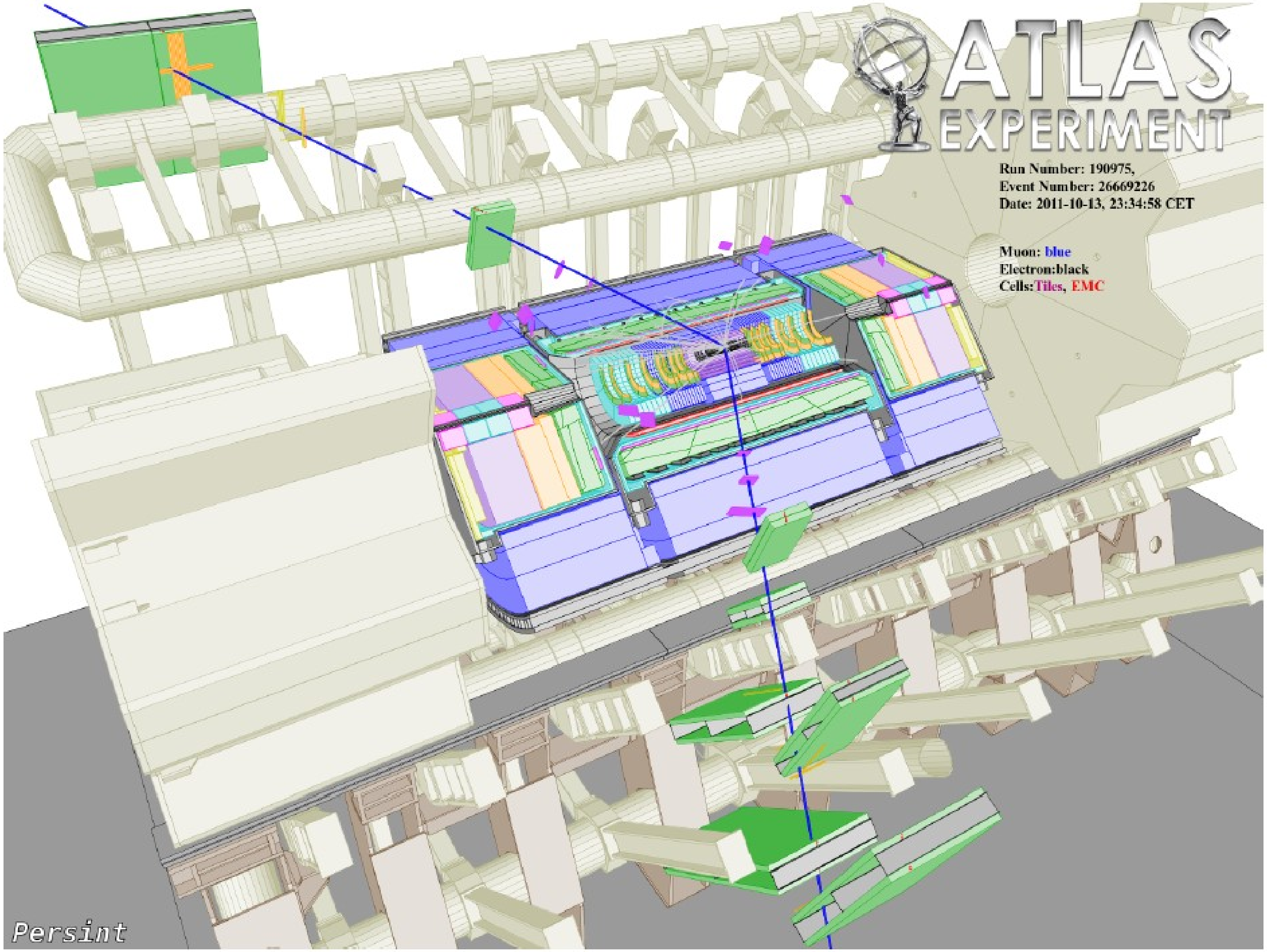



Figure 8: Event display for the dimuon candidate with the highest reconstructed invariant mass ($m_{\mu\mu}$=1.25 TeV). The muon with highest momentum has a $p_{\mathrm{T}}$ of 648 GeV and an $(\eta, \phi)$ of (-0.75, 0.49). The subleading muon has a $p_{\mathrm{T}}$ of 583 GeV and an $(\eta, \phi)$ of (-0.36, -2.60). The event missing transverse energy is 67 GeV, with a $\phi_{MET}$ of -2.83.

# BSM: dijet

- Select dijet events, look for bumps in invariant mass spectrum
  - May signal excited quarks, quantum black holes, ...