

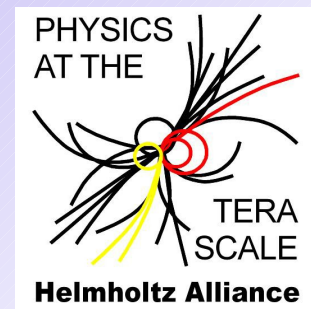


Exotic Searches in Top and Top-like Final States with the ATLAS Detector

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DESY

on behalf of the ATLAS Collaboration

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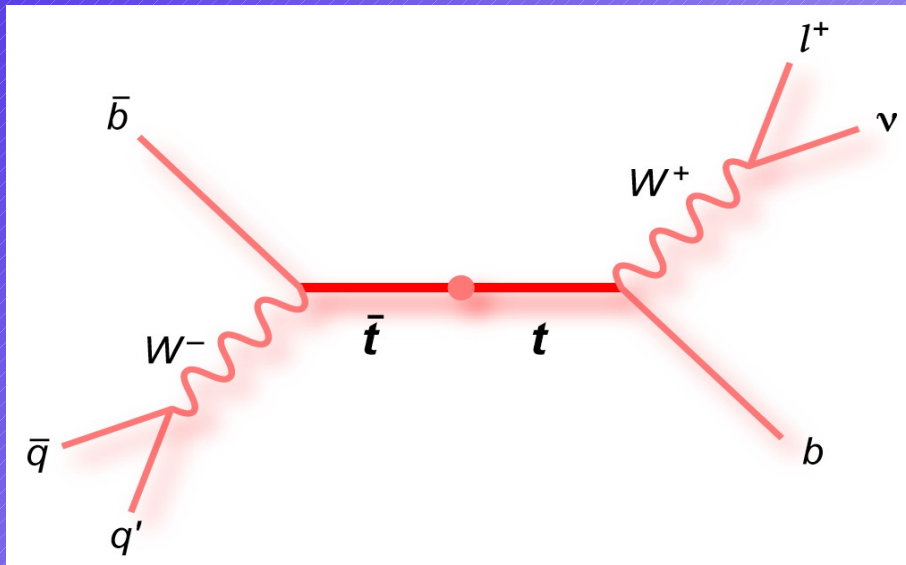


Overview



Top is heaviest standard model particle:

Exceptional status for new physics, especially if new physics couples to the mass

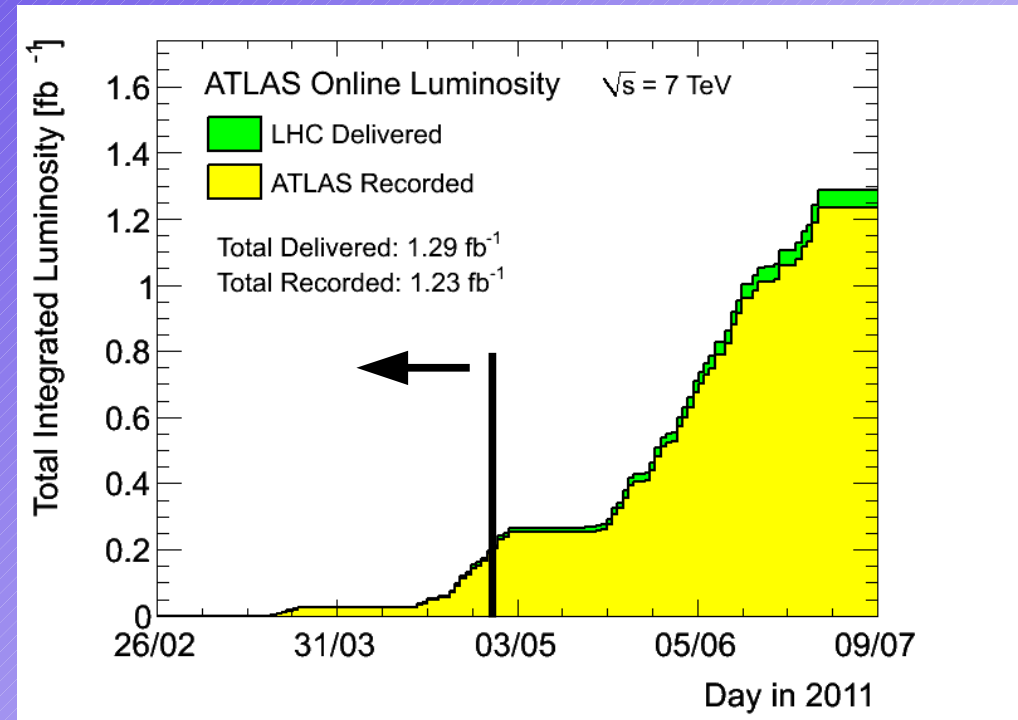
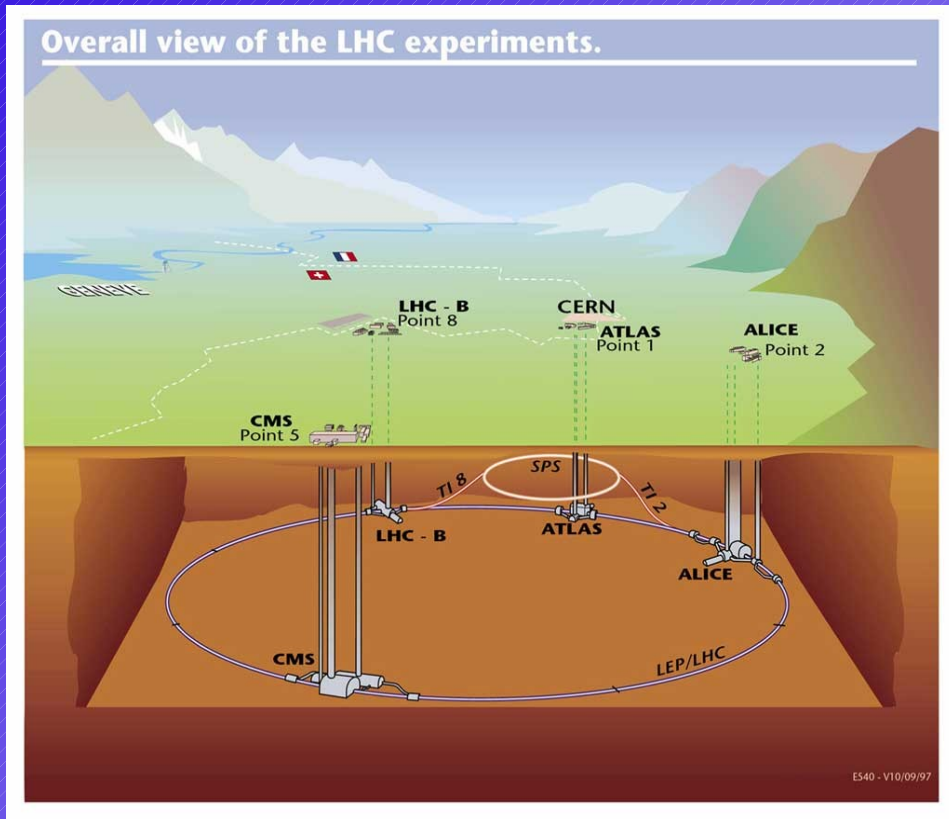


Search for new, exotic physics:

- Resonant Top-pair production: (ATLAS-CONF-2011-087, ATLAS-CONF-2011-073)
- Excess at high m_{tt} (black holes)(ATLAS-CONF-2011-070)
- Top-Pairs + Missing energy (ATLAS-CONF-2011-070)
- Heavy top like particles: 4th Generation quarks (ATLAS-CONF-2011-022)
- Production, decay and properties of Top (FCNC, Top-charge ... not part of this talk)

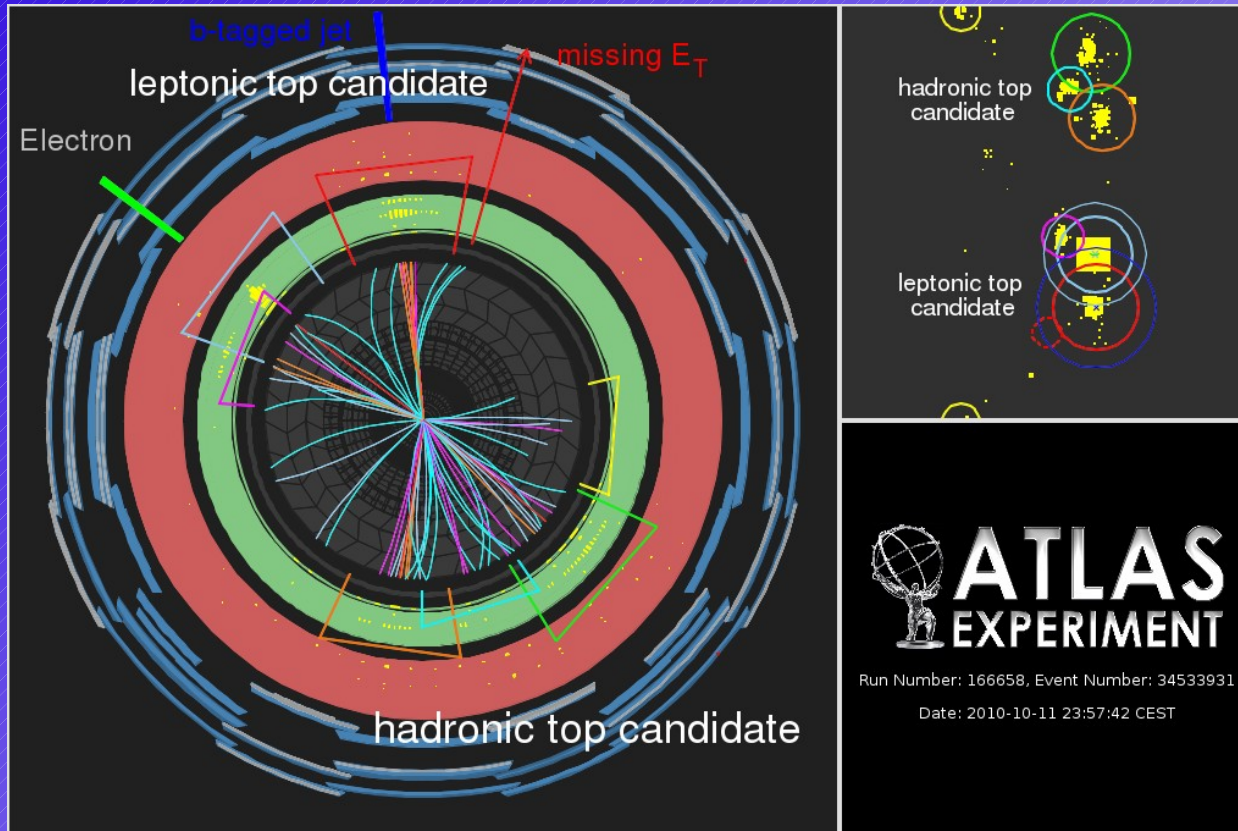


Data Set



- LHC: Excellent performance of the machine at 7 TeV, $\sim 1.3 \text{ fb}^{-1}$ of data delivered per experiment
- This talk contains results based on luminosity of 35-200 pb^{-1}

Resonance searches: Signal signature

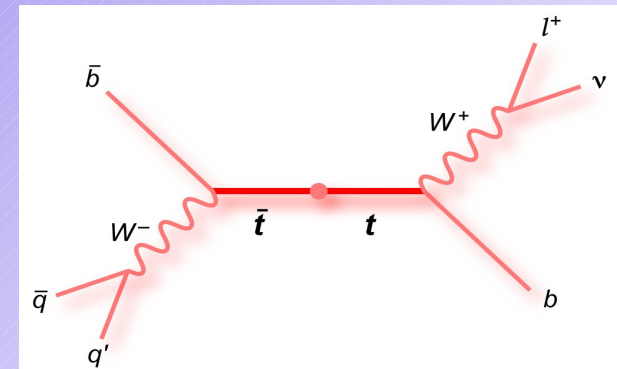


Resolved signature:

- 1 lepton (e or μ)
- At least 4 jets
- At least 1 b-tagged jet
- Covered $\sim 36\%$ of all SM top pairs decays (Lepton essential for trigger and QCD reduction)

At high m_{tt} :

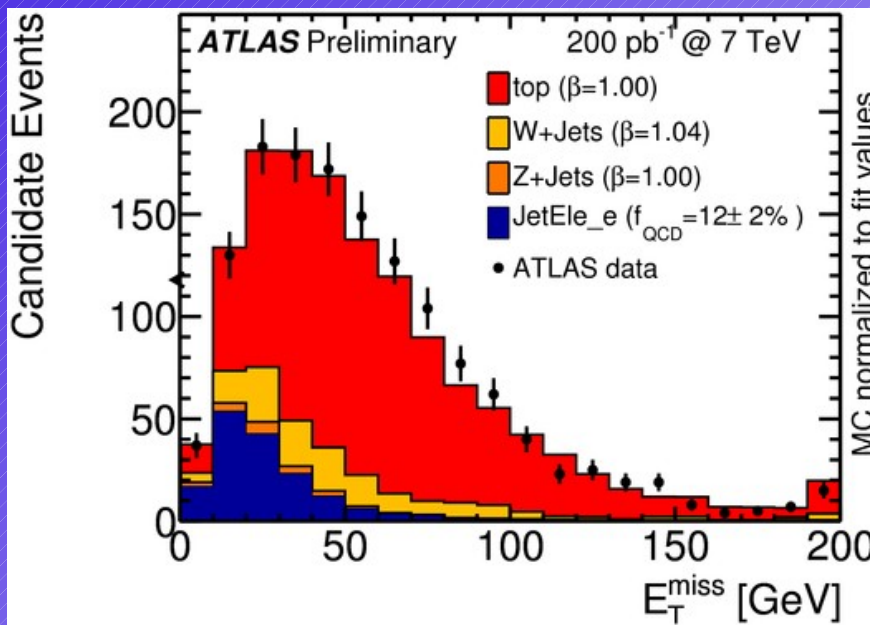
- Top pairs get more and more p_T (boosted tops)
- objects (leptons and jets) merge \rightarrow monojets



Backgrounds

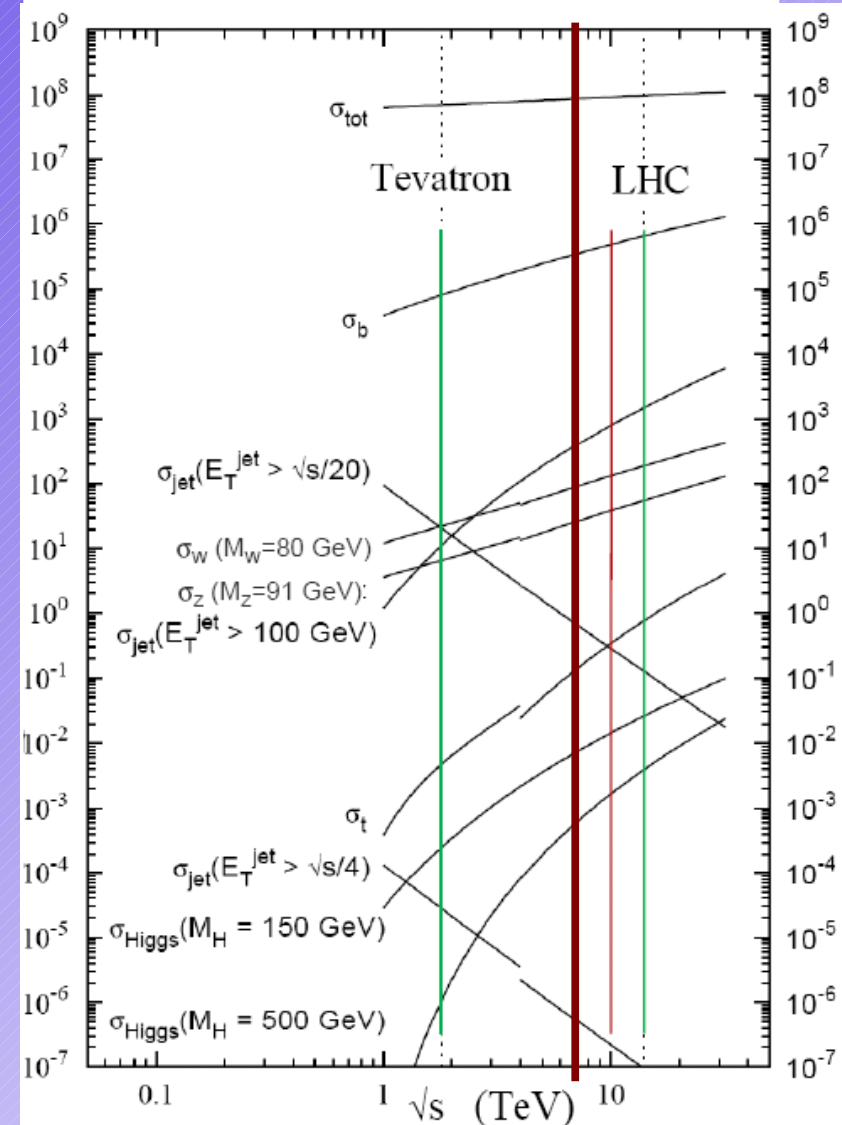
Main backgrounds:

- Ttbar (basically irreducible)
- W+jets (rejection via b-tag)
- QCD Multijet (no real leptons)



QCD background cross section/rejection not well modeled by Monte Carlo:
 → need (semi-)data driven background estimate; fit of QCD template from data to E_t^{miss} distribution

Proton-Proton cross section in pb





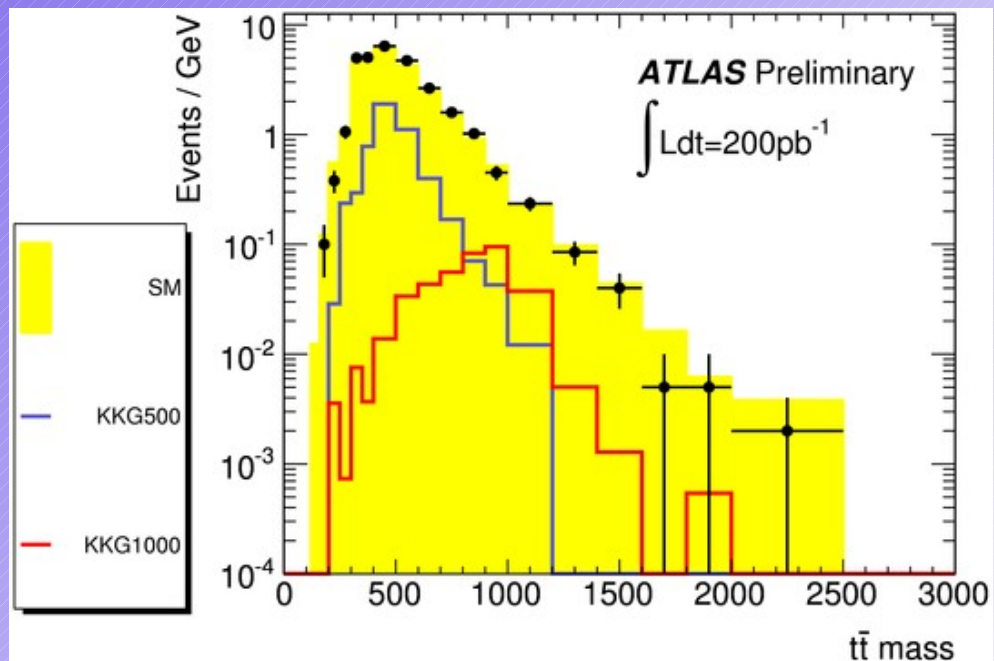
Mass reconstruction



Use simple and robust mass reconstruction schema:

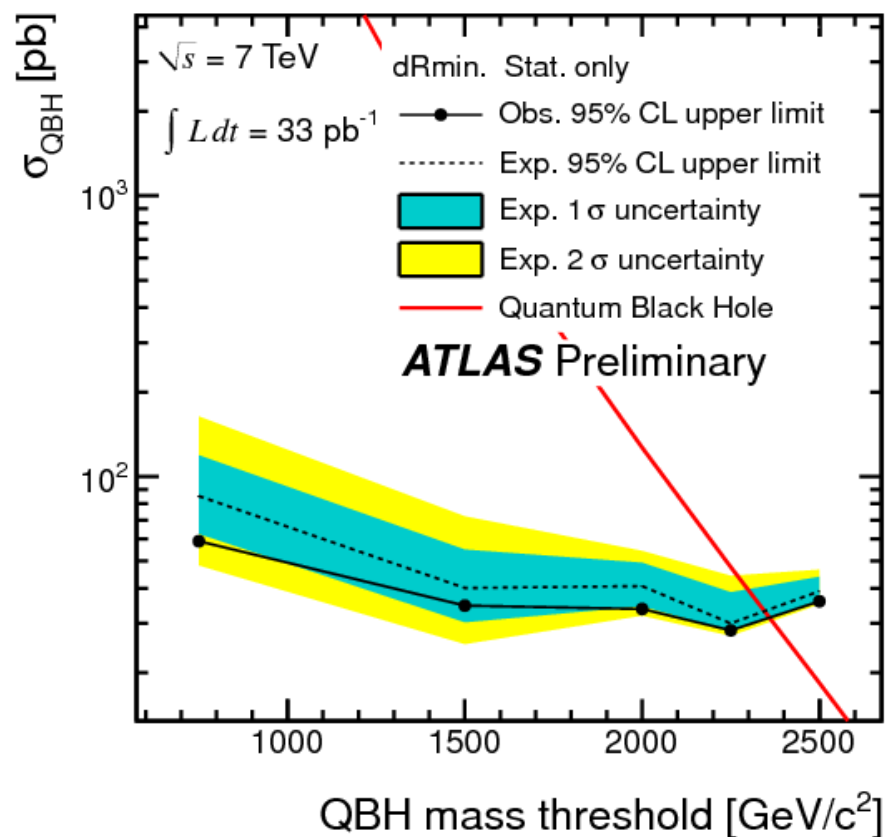
- Reconstruct full final state instead of two separate tops
 - Using 4 leading jets for m_{tt} leads to a long tail in resolution (initial state radiation)
- better: $\Delta R(\min)$ method: exclude jets which are clearly separated from other jets/lepton (good ISR candidates)

	Electron channel	Muon channel
$t\bar{t}$	724	988
Single top	36	50
W+jets	93	172
Z+jets	6	8
Diboson	2	2
Total MC Background	861	1220
QCD Background	35	105
Total Expected	896	1325
Data observed	935	1396
$Z', m = 500 \text{ GeV}$	15	21
$g_{KK}, m = 700 \text{ GeV}$	68	93





Black hole limits



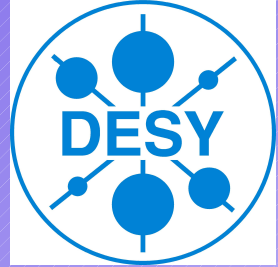
Black holes:

- First Limit from Atlas from $t\bar{t}$ high mass analysis
- Black holes decaying via strong gravitational scattering (JHEP 0805 (2008) 003, JHEP 0805 (2008) 003)
- 24-38% BR (750-2500 GeV black hole threshold mass) of $t+X$ and low parton multiplicity
- \rightarrow Looking for an excess of tops at high $m_{t\bar{t}}$

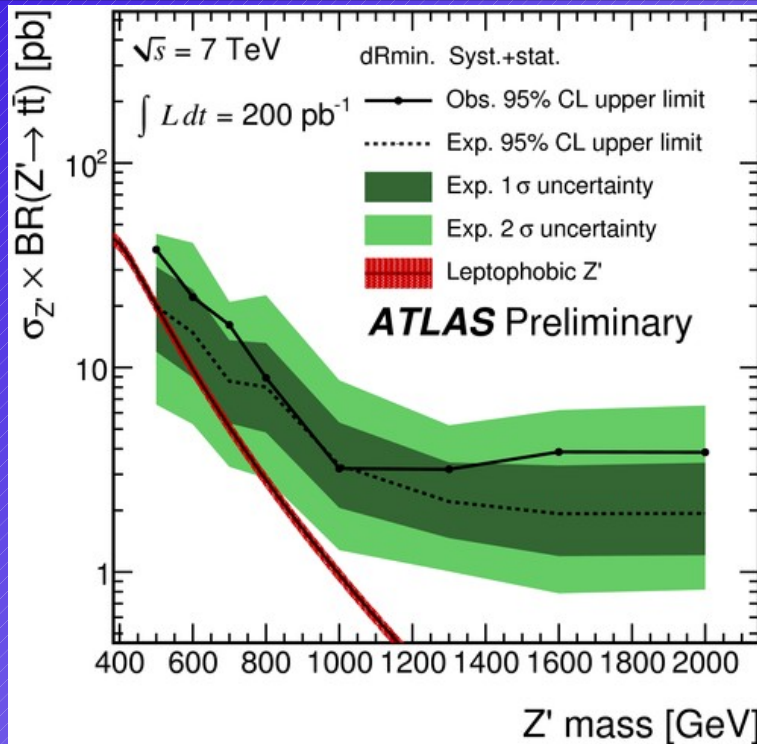
Exclude quantum black hole mass thresholds below 2.35 TeV



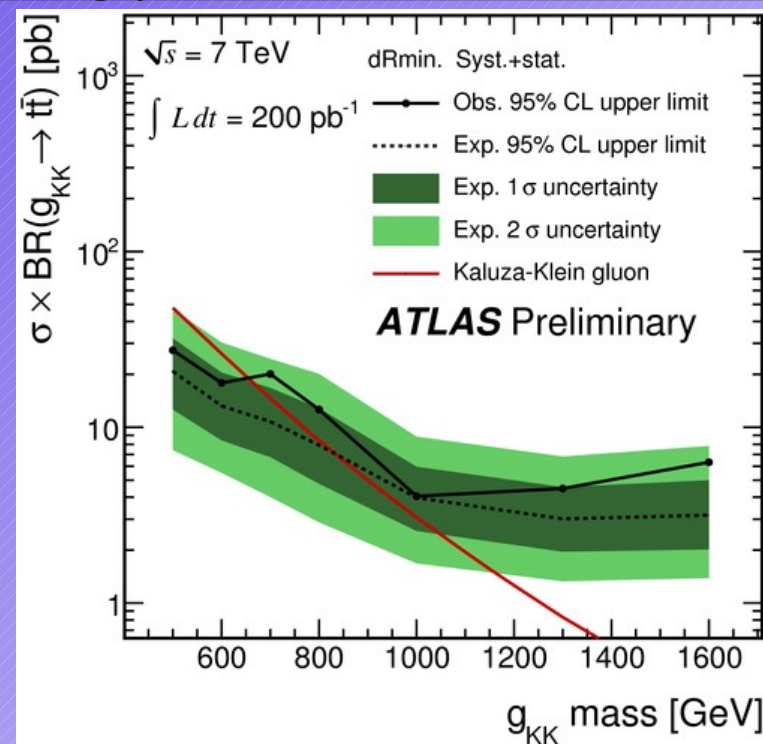
Limits for resonances



Narrow Z' produced weakly



Wider Kaluza-Klein-Gluons produced strongly



Leptophobic Top-Color:

- arXiv:hep-ph/9911288;
- No exclusion up to now (200 pb^{-1})
- Tevatron exclude $m_{tt} \sim 900 \text{ GeV}$ with $3\text{-}5 \text{ fb}^{-1}$ lumi

Randal-Sundrum Modell:

- arXiv:hep-ph/0701166; ATL-PHYS-PUB-2010-008;
- Exclude low masses ($< 700 \text{ GeV}$)

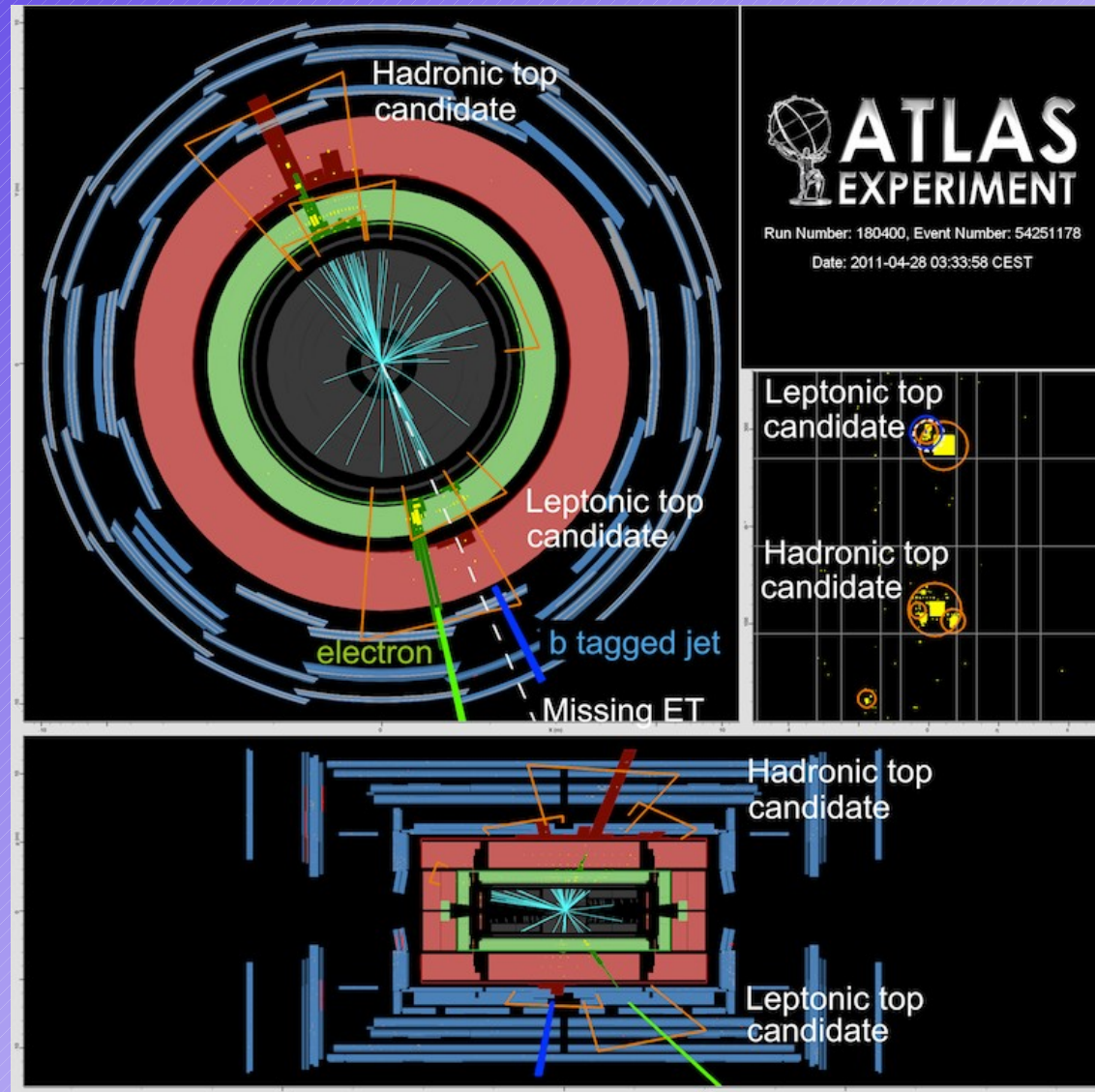
Heavy Resonances: Boosted top pairs

Candidate with $m_{tt} \sim 1.6$ TeV:

- Tops get heavily boosted
- Partons only just in separated jets
- Higher m_{tt} need other reconstruction strategy than standard top selection
→ fat jets including all partons

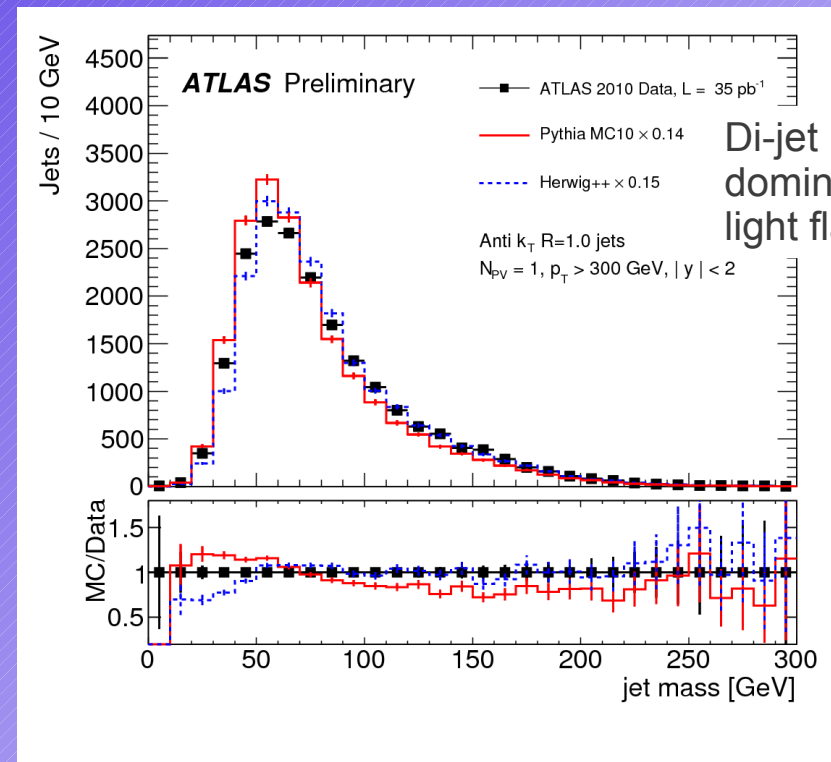
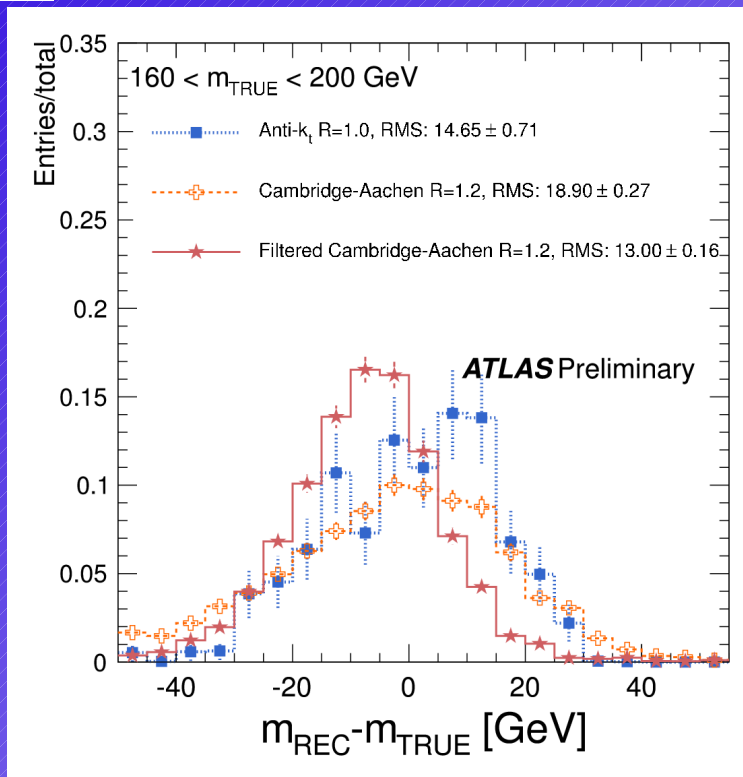
First step:

- Reconstruction of hadronic top as one fat object





Boosted top quarks: substructures



In Simulation final states with $m_{\text{jet}} \sim m_{\text{top}}$ have a good jet-mass resolution

- Pile up is biggest problem:
 - influences anti-kt 1.0; needs calibration
 - Cambridge-Aachen seems less affected
- Jet mass in data described reasonably by Pythia and Herwig



Top-Pairs plus missing



E_T^{miss}

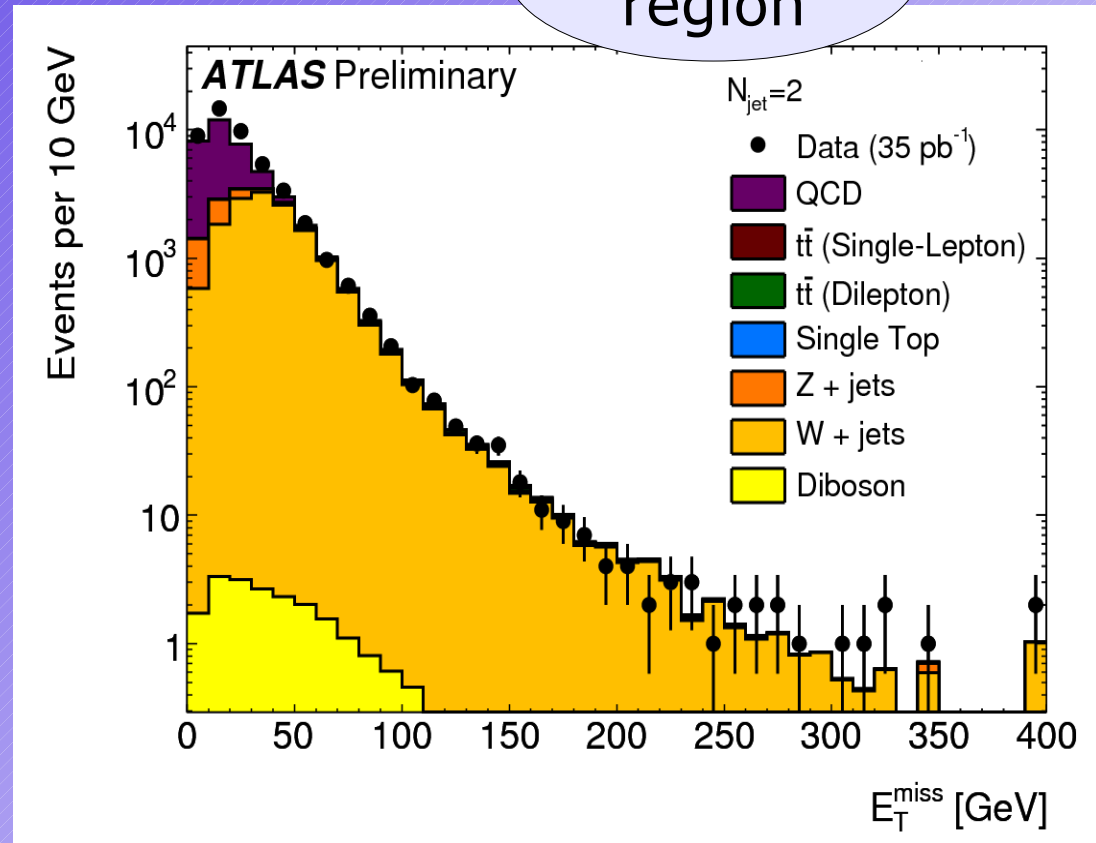
- Example: $TT \rightarrow ttA_0A_0$

Top Quarks plus missing E_t^{miss}

- Sensitive to production of heavy particle decaying into Top quarks plus additional neutral particles
- Essential: Good knowledge of missing E_t
- Early studies have low statistics \rightarrow validate background in lower n_{jet} bin (here $n_{\text{jet}}=2$).

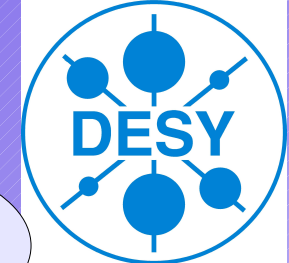
\rightarrow good agreement between data and Monte Carlo

Control region





Top-Pairs plus missing



E_T

Signal region

N-jet=4 low statistics

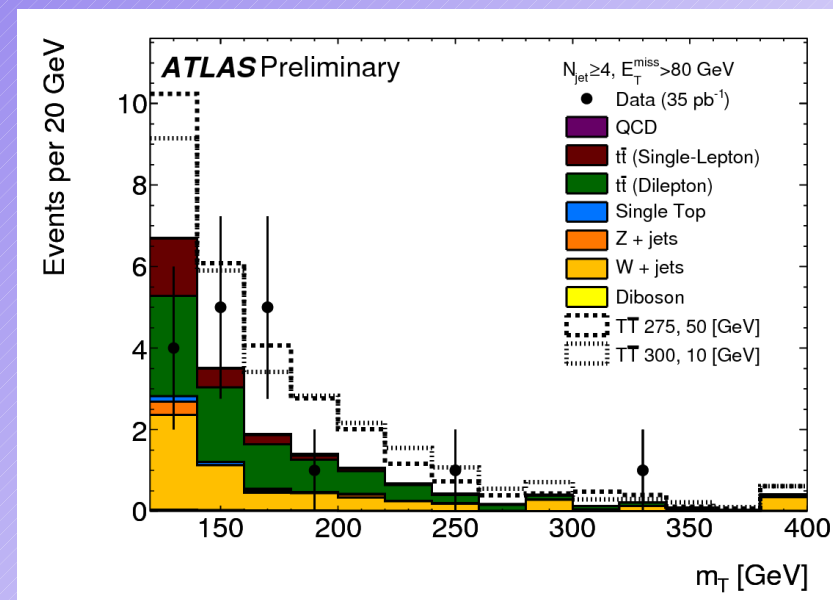
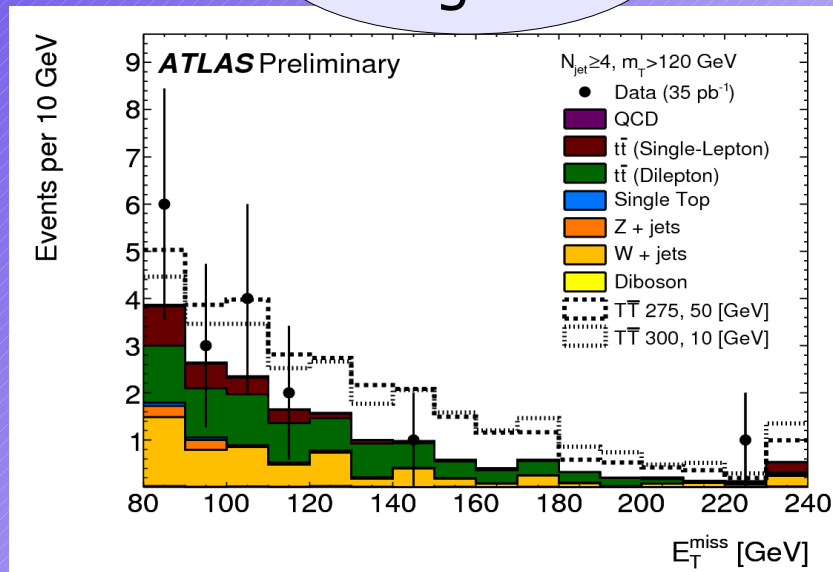
- Data-Monte Carlo comparison fair agreement

Transversal Mass distribution

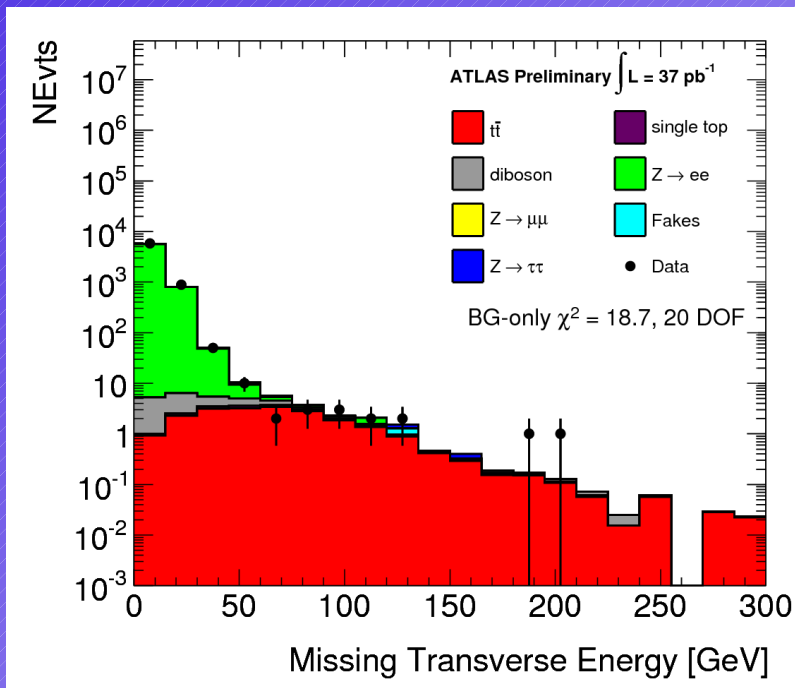
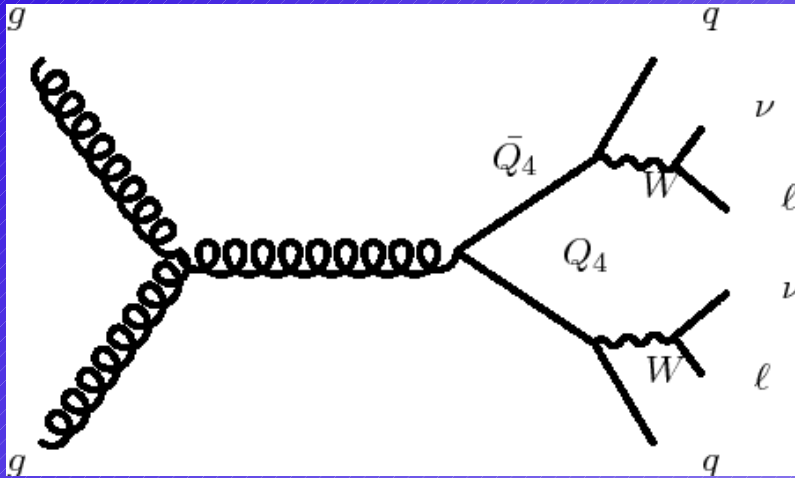
- No signal of heavy particle seen

→ Exclusion with 35 pb^{-1} (cut and count, simple model of quark like objects decaying to top plus heavy neutral particle arXiv:0909.3555):

- 275 GeV T decaying into top and 50 GeV A_0
- 300 GeV T decaying into top and 10 GeV A_0



4th generation quarks



Natural extension of Standard Model

- Add CP violation for baryon asymmetry
- Higgs naturalness problem

Top like: Q_4 decaying into Wq
(arXiv:0907.3155, $\sigma(m \approx (300 \text{ GeV})) \sim 5 \text{ pb}^{-1}$)

- Does not test Q_4 charge: sensitive to $4/3 \dots -1/3$ charged 4. generation quarks

Final state has heavy top pair signature:

- 2 leptons
- 2 jets
- Missing E_T (\rightarrow plot for ee)
- higher boost of the decay products

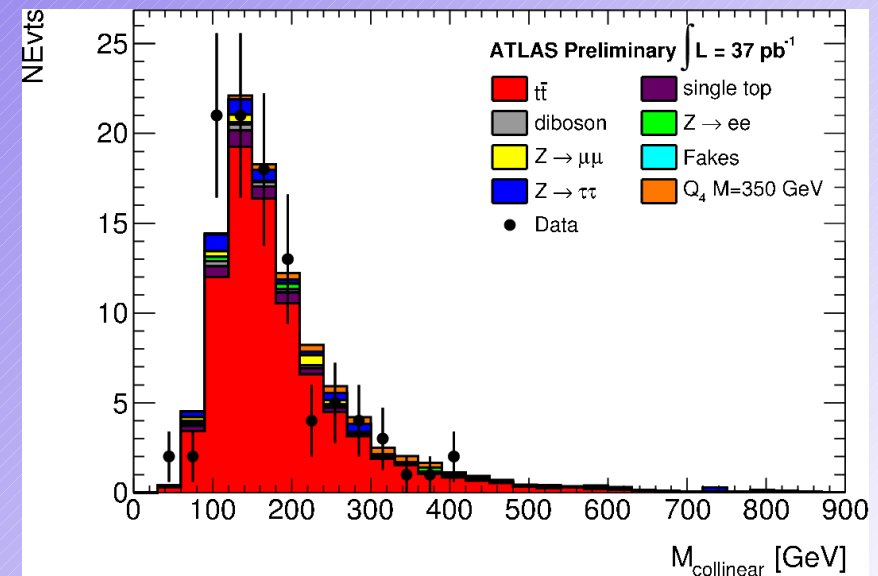
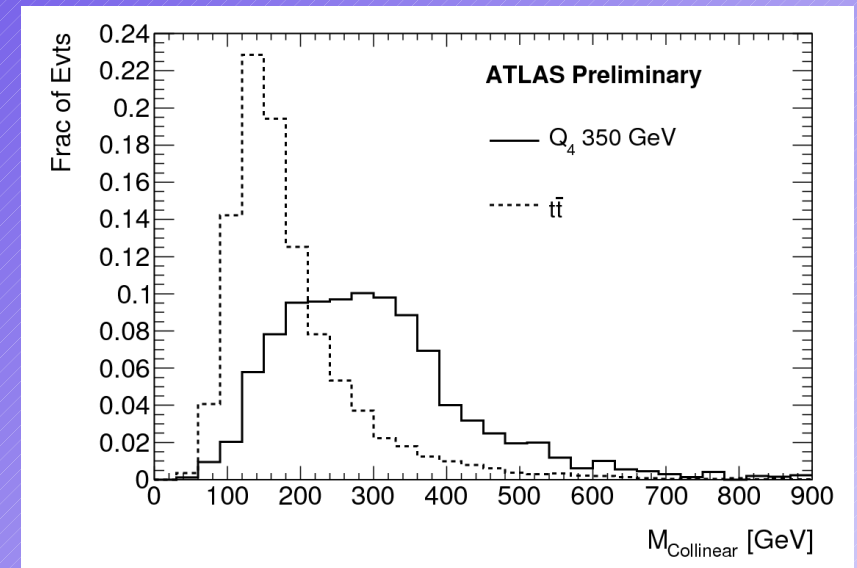


4th generation quarks: mass



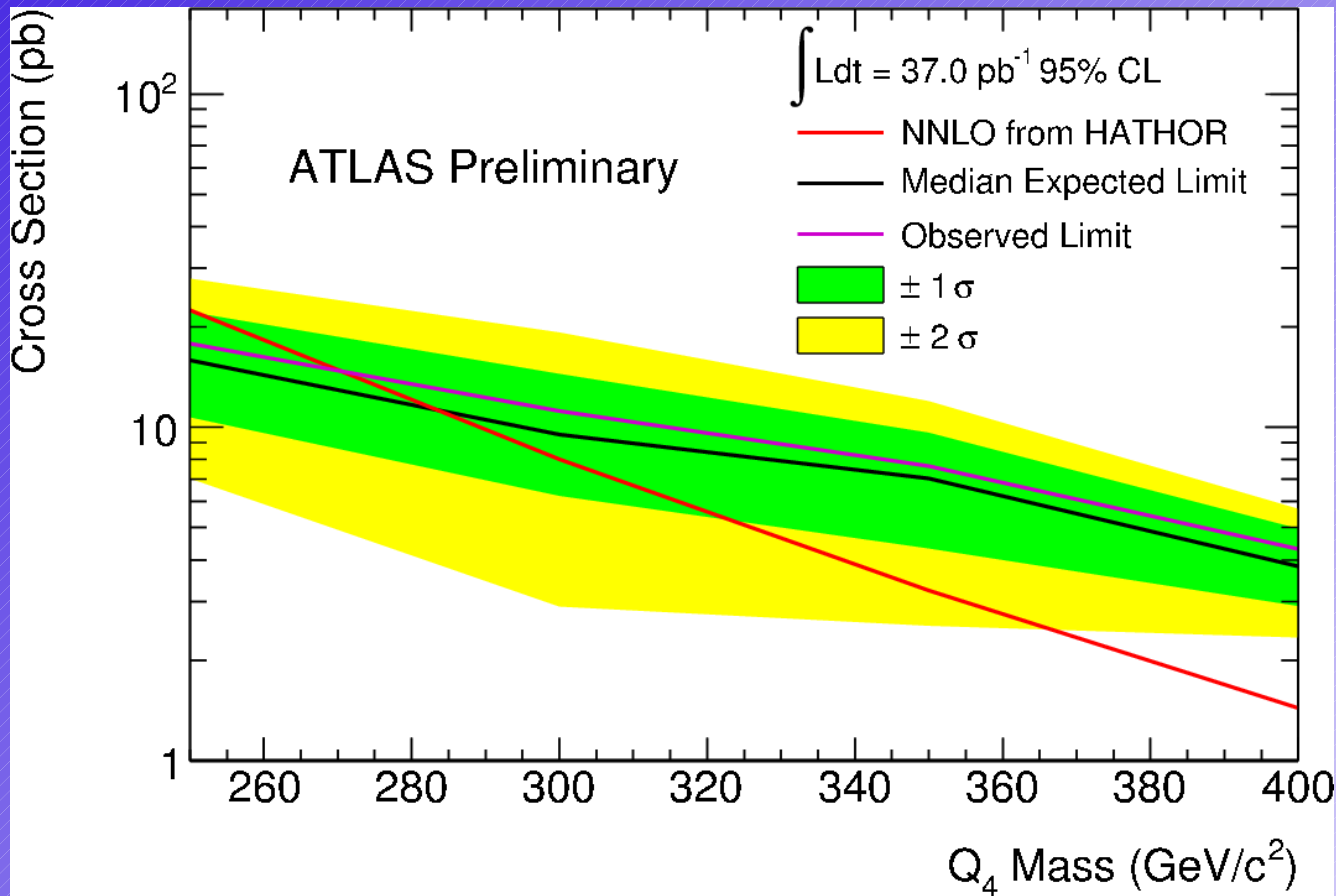
Collinear mass (neutrino has same flight direction like lepton) shifted vs top-pair final state:

→ looking for a very broad excess in the mass distribution
Data agreement for 37 pb^{-1} quite reasonable





4th generation quarks: Limits



Limit on production cross section of Q_4 for 37 pb^{-1} :

→ Translates to lower mass limit: $M_{Q_4} > 270 \text{ GeV}$

(Best Tevatron limits (CDF, 4.6 fb^{-1} : $m_{Q_4} > 335 \text{ GeV}$))



Summary



- LHC ideal for studying exotic physics in top final states
 - X-section much bigger than at Tevatron
 - Already collected more than 1 fb^{-1} of luminosity per experiment
- Many exotics top-like final states already studied:
 - Resonances decaying into top-pairs:
 - Digging into allowed phase space
 - Tevatron sensitivity soon in reach
 - Exclude low mass black holes
 - Top-pairs plus missing E_T :
 - first exclusions at ATLAS
 - Shown first ATLAS limits on 4. Generation quarks
- More data already taken \rightarrow analyses are being updated
- New upcoming analysis boosted tops are upcoming with the higher sensitivity range