Top and exotics news from ATLAS.

Overview

Introduction

* Part 1: SM top measurements

ttbar cross section

Jet multiplicity in ttbar events

* Part 2: Searches for new physics

Top quark pair resonances

Same-sign top and fourth generation searches

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for ATLAS

Why top and exotics?

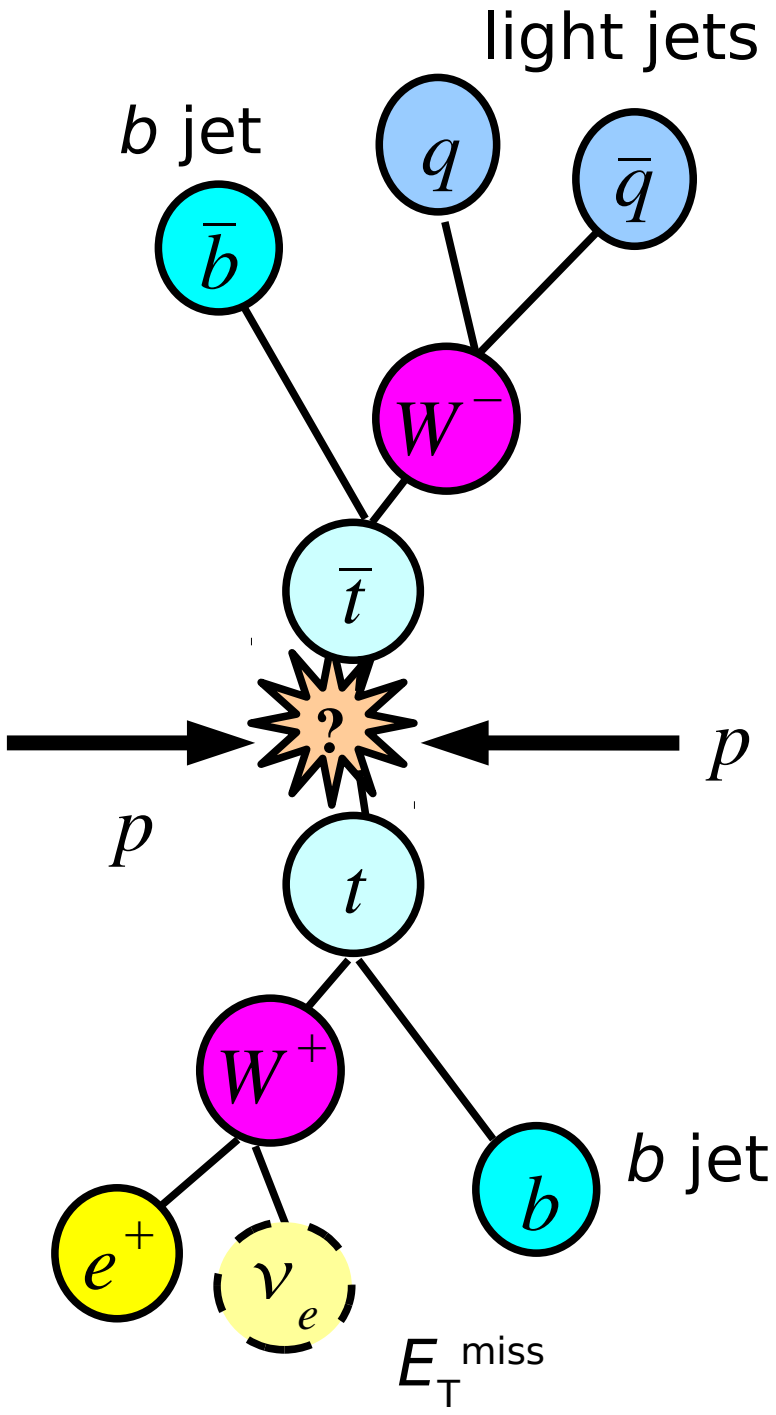
- Top is heavy (M ~173 GeV/c^2), close to EW symmetry breaking scale.
- Potential interesting new physics in top events.
  - What about top pair resonances? Like $Z^0 \rightarrow q\,\bar{q}$
  - Fourth generation quarks?
  - Same-sign tops?

Nomenclature:

l+jets: $t\bar{t} \rightarrow Wb+Wb \rightarrow l\nu b+bq\bar{q}$ ($l = e, \mu$)

dilepton: $t\bar{t} \rightarrow Wb+Wb \rightarrow l\nu b+l\nu b$

all-had: $t\bar{t} \rightarrow Wb+Wb \rightarrow bq\bar{q}+bq\bar{q}$

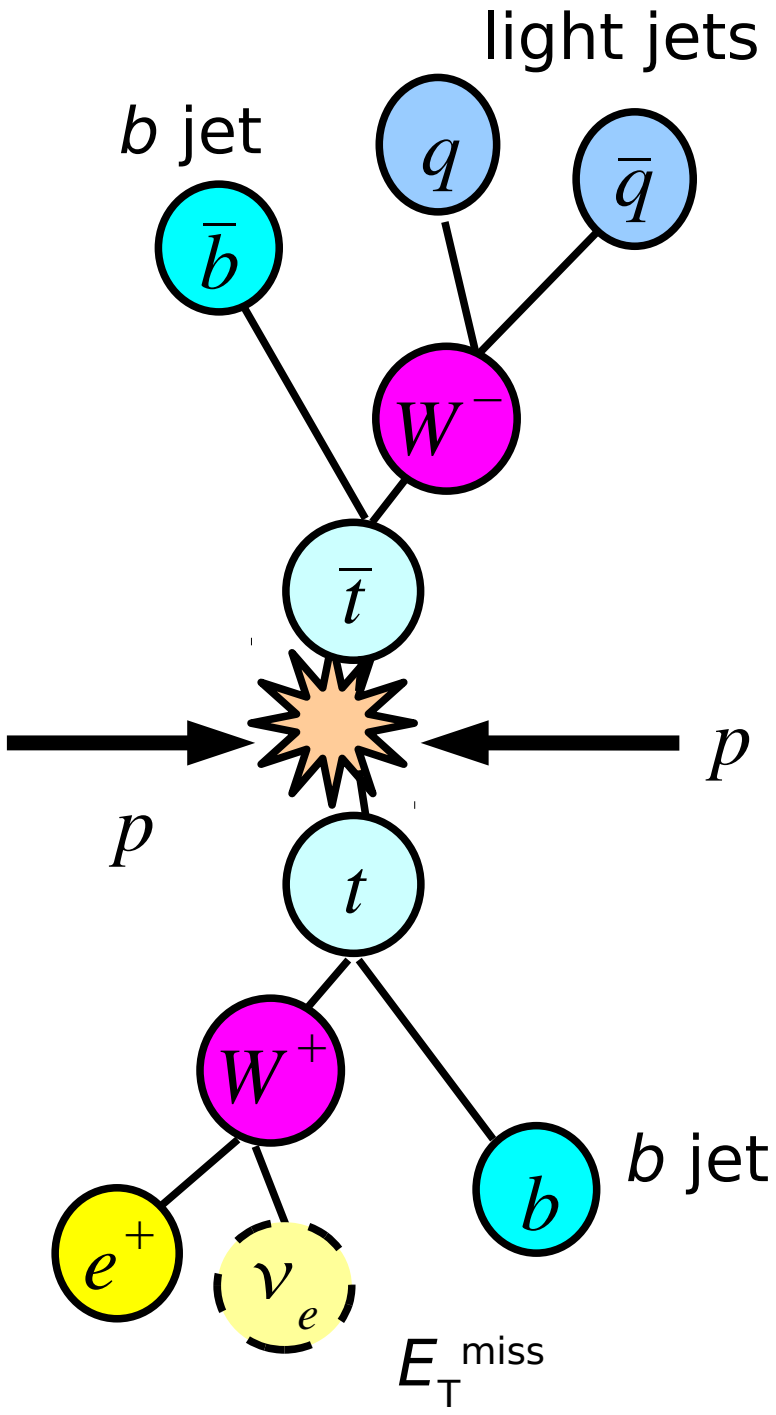


Top reconstruction strategies

- dilepton (BR ~6%):
  - Trigger on one of the leptons
  - Exactly two leptons
  - Require E_T^{miss} from the ν's
  - 2 jets from b quarks
  - $m_{ll} \sim m_Z$ mass veto (dileptons)
- l+jets (BR ~38%):
  - Trigger on the lepton
  - Exactly one leptons
  - Require E_T^{miss} from ν
  - 4 jets (2 from b quarks)
- All-hadronic (BR ~56%):
  - Trigger on multi-jets
  - 6 jets (2 from b quarks)

b-tagging to ID b-jets:
typically ~60% efficient

Jets: anti-k_t algorithm, R=0.4



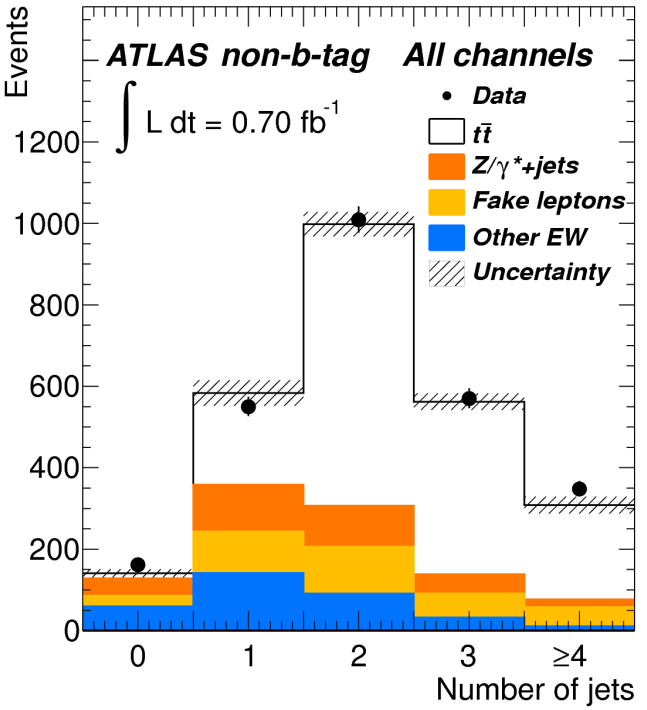
SM top physics

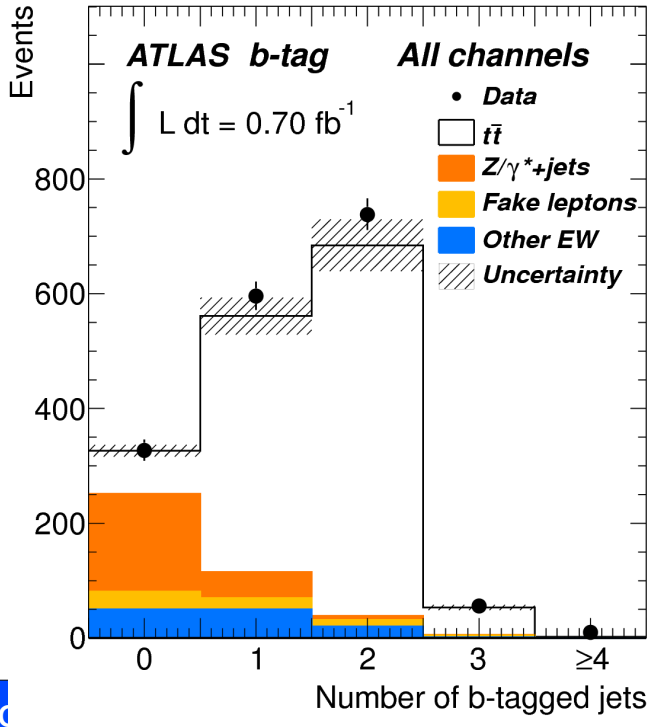
$t\bar{t}$ cross section measurement in the dilepton channel (0.7 fb^{-1})

CERN-PH-EP-2011-223

Cross section value: important for other measurements.
Deviations from SM prediction could indicate new physics!
Clean channel. Low BR.

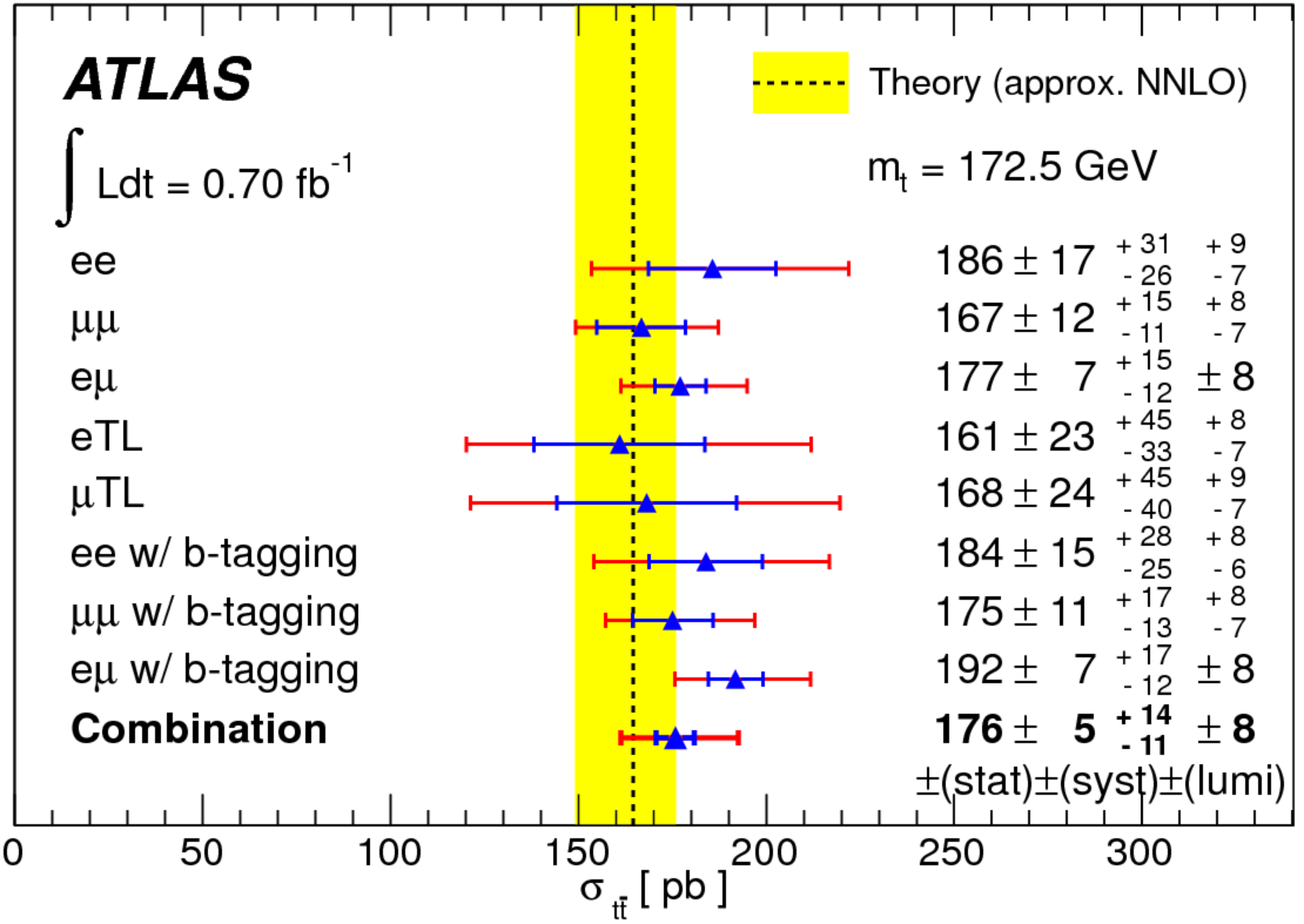
- Event selection:
  - 2 central high-p_T leptons (e or μ), opposite charge
    OR 1 charged lepton + 1 loose lepton (TL)
  - 2 jets $p_T > 25$ GeV and $|\eta| < 2.5$. Possible b-tagging
- Dominating systematics:
  - Generator dependence (early measurement)
  - Lepton scale and reco uncertainties
  - Jet and E_T^{miss} uncertainties
  - Luminosity





$t\bar{t}$ cross section in the dilepton channel (cont.)

Cross section obtained through a profiling likelihood technique.



Theory: $\sigma_{t\bar{t}} = 165^{+11}_{-16}$ pb. (M. Aliev et al "HATHOR" arXiv:1007.1327).

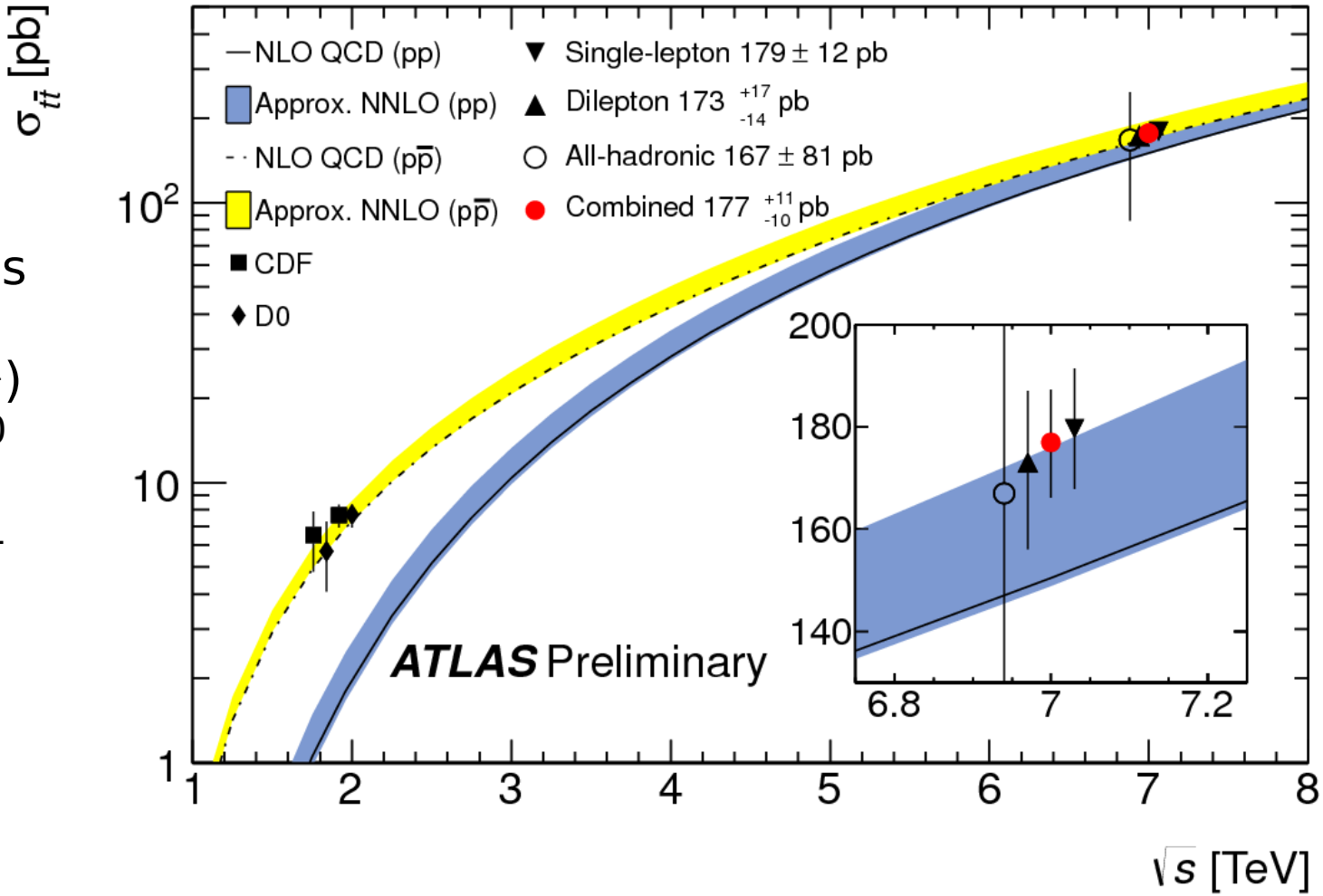
Top cross section – combined

ATLAS-CONF-2012-024

Combination of

- dileptons (previous slide)
- all-hadronic (1 fb^{-1}) ATLAS-CONF-2011-140
- l+jets (0.7 fb^{-1}) ATLAS-CONF-2011-121

Combination with a likelihood profile technique, 89 parameters.



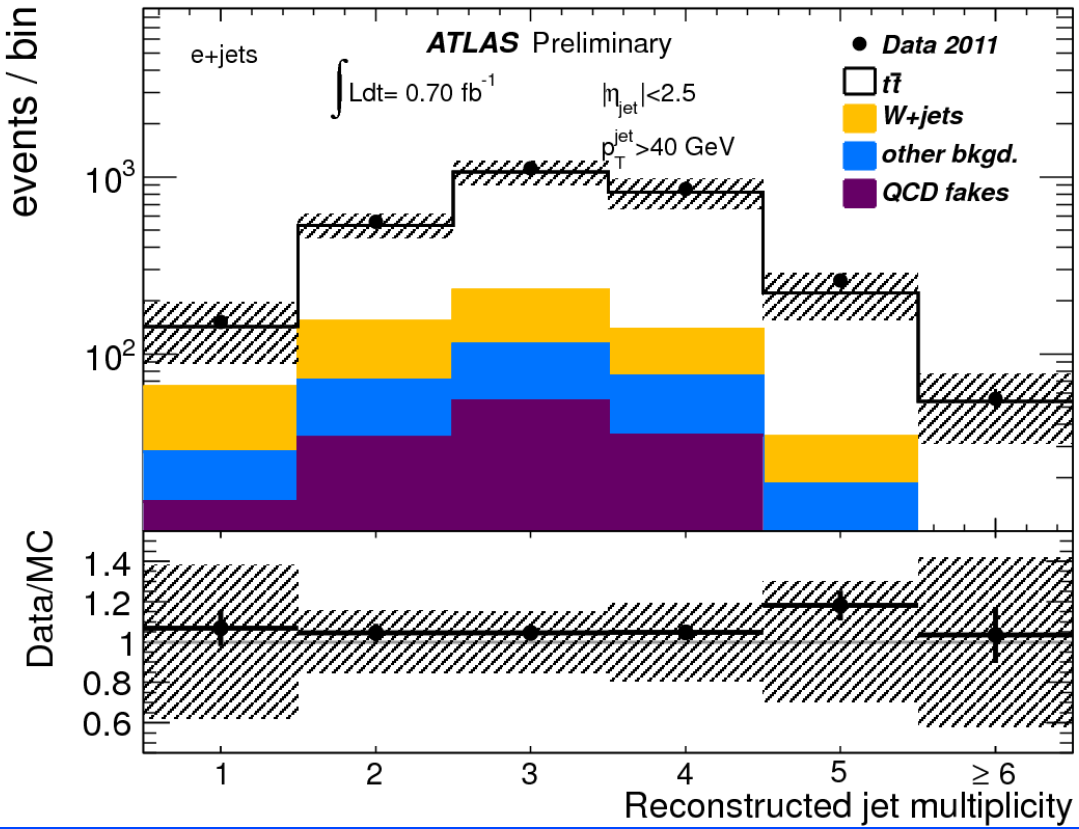
$\sigma_{t\bar{t}}$ = 177 ± 3 (stat.) +8/-7 (syst.) ± 7 (lumi.) pb

CMS: 165.8 ±2.2 (stat.) ±10.6 (syst.) ±7.8 (lumi.) pb (TOP-11-024 ~1fb^{-1})

Jet multiplicity in $t\bar{t}$ events

ATLAS-CONF-2011-142 (0.7 fb^{-1})

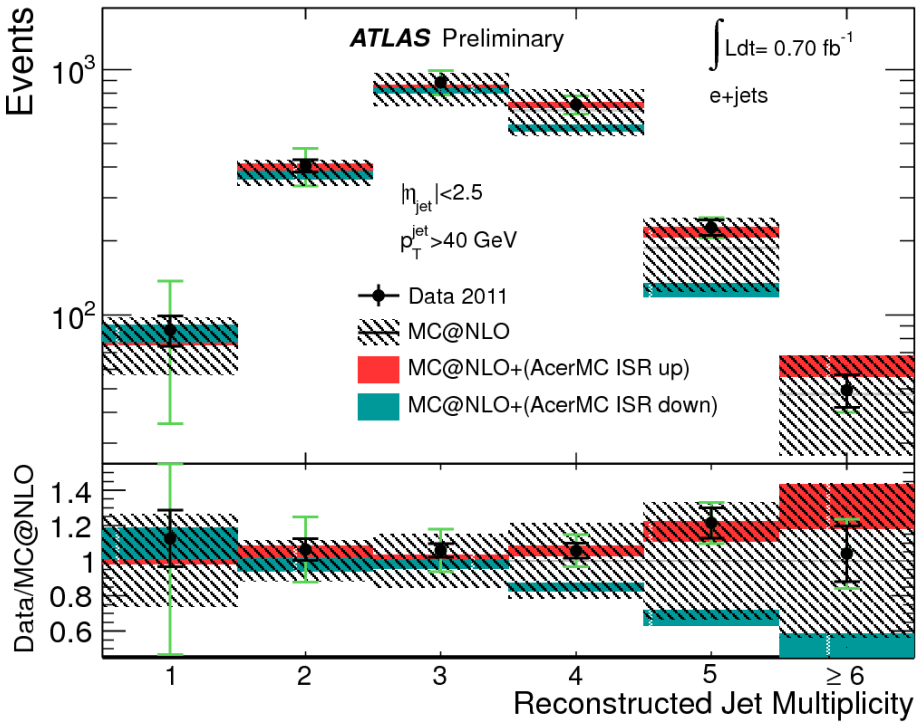
- l+jets ttbar decays
- Test of pQCD, monitor ISR/FSR (parton shower activity)
- Also important background of potential new physics
- Event selection:
  1 lepton (e or μ)
  E_T^{miss}
  >= 4 jets
  at least 1 b-tag (50% eff)
  Jet p_T>25 GeV, 40 GeV or 60 GeV.

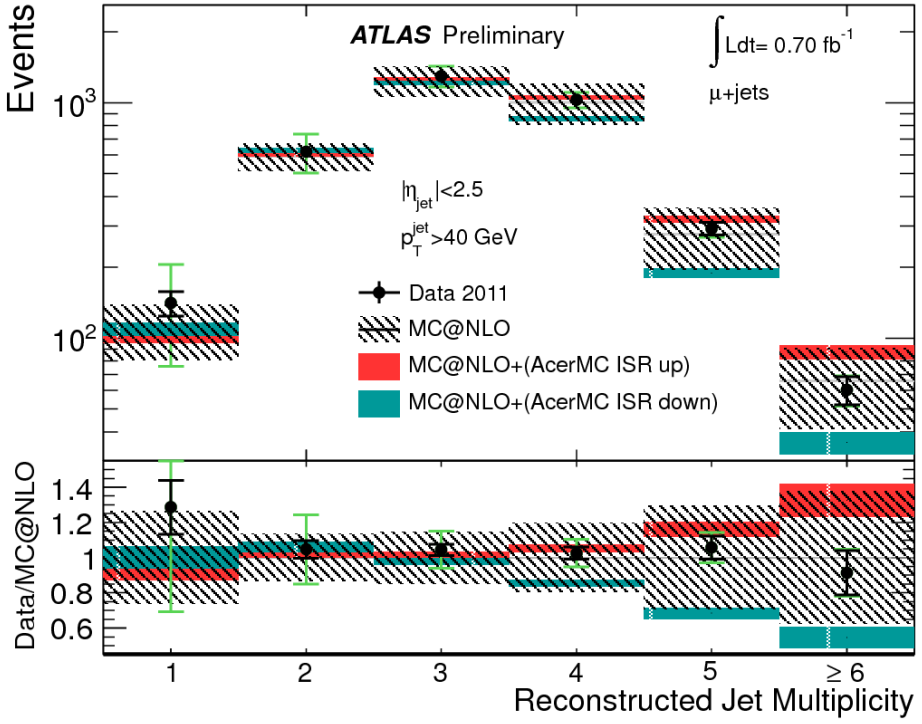


e+jets, jet p_T> 40 GeV

Jet multiplicity in $t\bar{t}$ events (cont.)

- Data compared with MC@NLO predictions.
- AcerMC ISR/FSR modelling (LO)
- No deviations from the predictions are observed
- Dominated by systematics at low multiplicity and statistics at high multiplicity.
- Stay tuned for 5 fb^{-1} results!





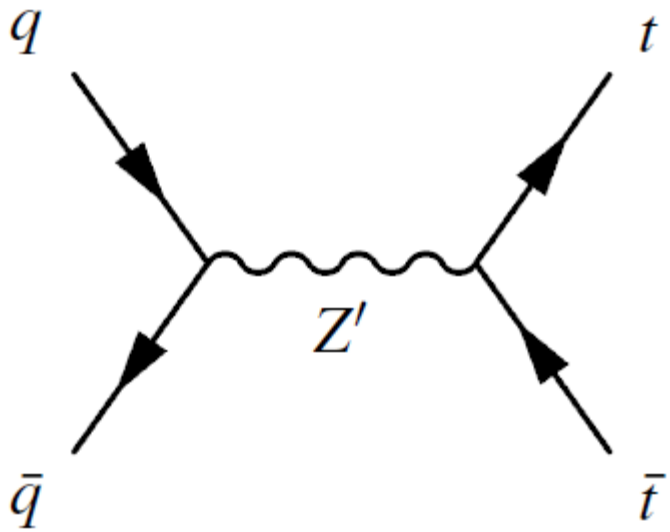
Top and new physics

$t\bar{t}$ resonances

ATLAS-CONF-2012-029 ($2fb^{-1}$)

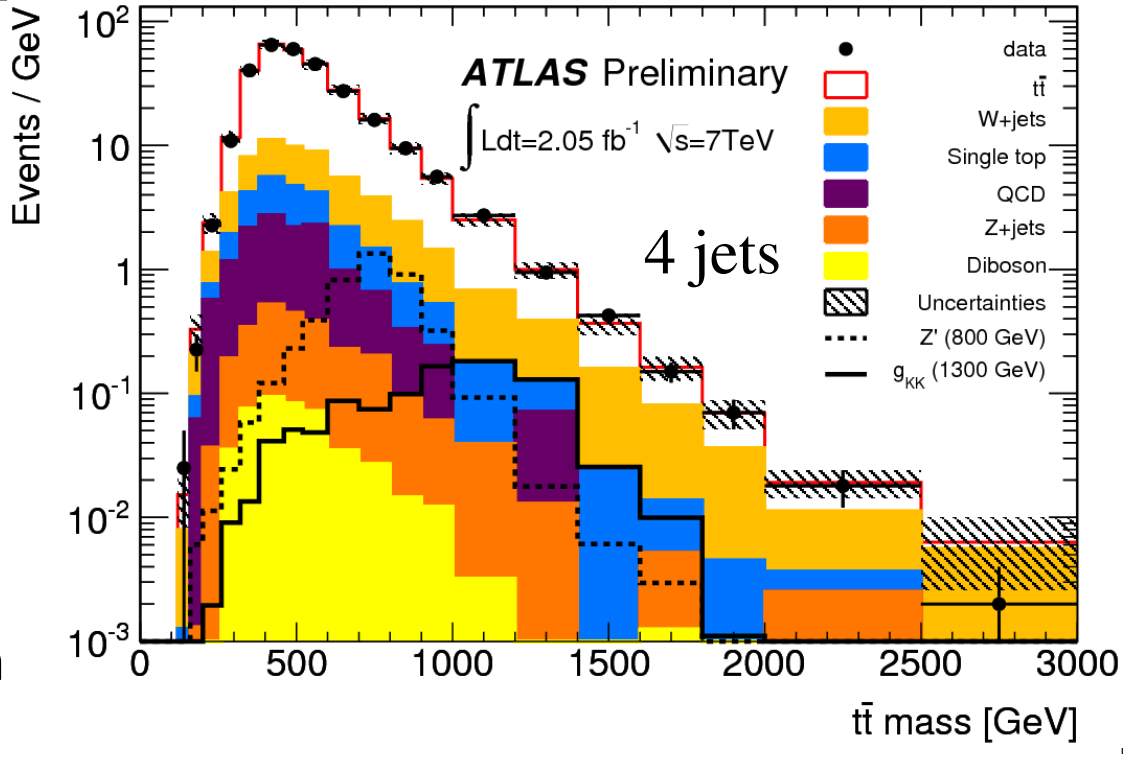
- Strategy: search the $M_{t\bar{t}}$ spectrum for bumps that could indicate a resonance (like $Z^0 \rightarrow q\bar{q}$)
- $t\bar{t} \rightarrow l$+jets
- Physics models considered:
  - *Colour singlet: leptophobic topcolor Z'* (heavy Z^0-like boson), $\Gamma/M \sim 1\%$
  - *Colour octet:* g_{KK} from a RS extra dimension, $\Gamma/M \sim 15\%$

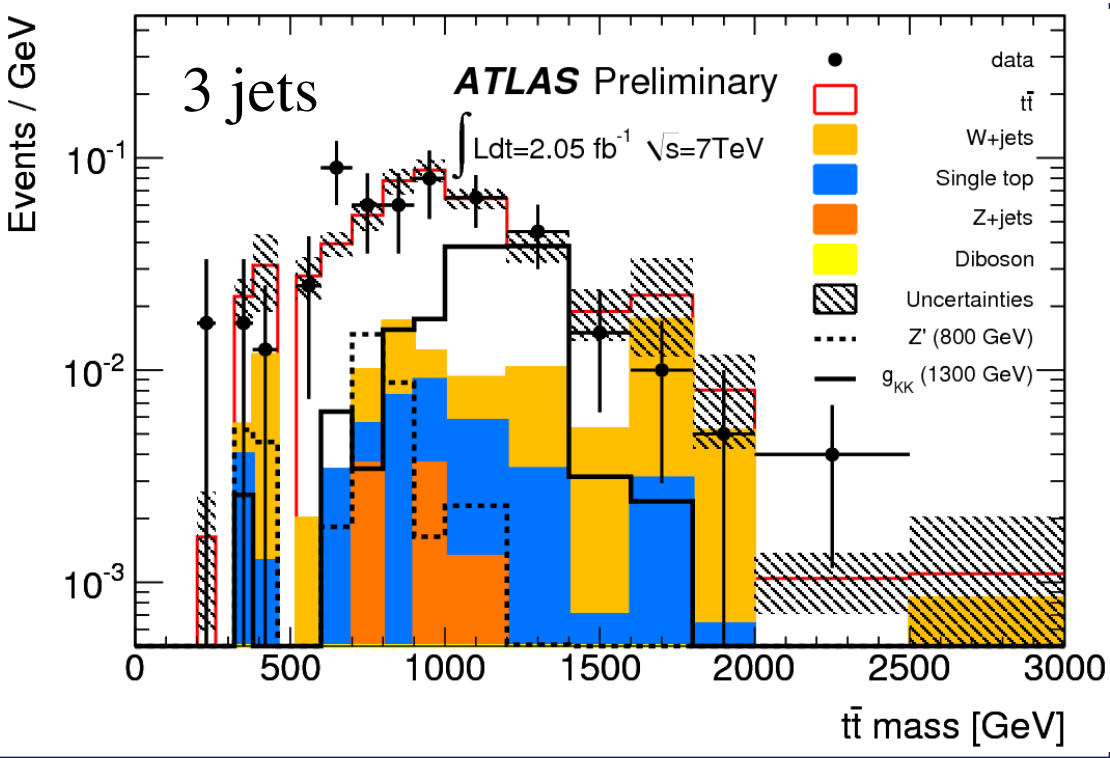
Generic models, and a generic search to find *any* bump in the $M_{t\bar{t}}$ spectrum.



$t\bar{t}$ resonances (cont.)

- Selection: 1 lepton (*e* or μ), 4 jets, at least 1 *b*-tag, E_T^{miss}.
- Compute $M_{t\bar{t}}$ using a *W* mass constraint on the $l+E_T^{miss}$ system
- Account for **boosted** tops: if m_j>60 GeV, require only 3 jets (bottom plot).
  Better S/B despite worse statistics!
- Search for bumps or dips with the BumpHunter (arXiv:1101.0390)
  No deviation found
  → Set limits

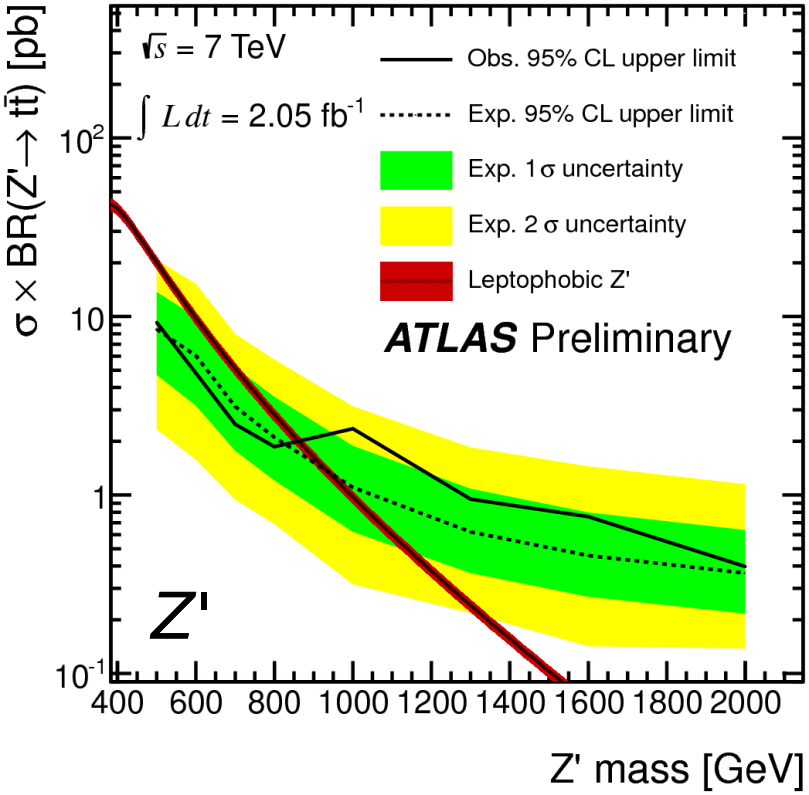


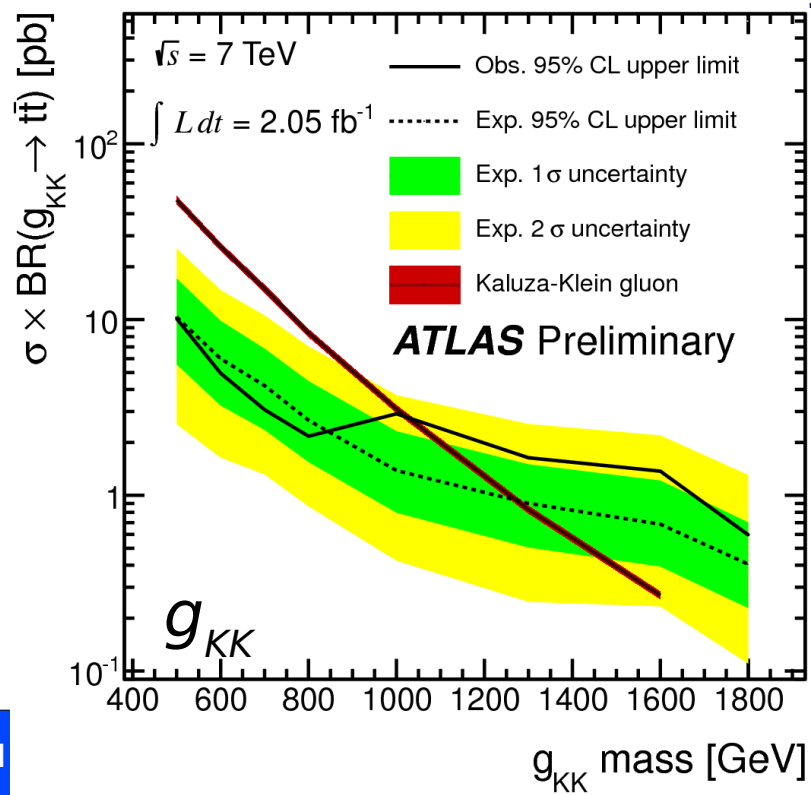


$t\bar{t}$ resonances (cont.)

- Bayesian* upper cross section limits on two benchmark models.
- Z' is narrow, weakly interacting: better upper limit, lower theory x-sec
  g_{KK} is broad, strongly interacting: worse upper limit, higher theory x-sec.
- Systematics: *b*-tagging, jet energy scale, jet energy res., ISR/FSR, lumi, x-sec.
- Mass exclusions (2 fb^{-1}):
  $m_{Z'}$>860 GeV
  m_{gKK}>1025 GeV
- Limits from a similar CMS study (5fb^{-1}; CLs limits, PAS-TOP-11-009):
  $m_{Z'}$>~1.3 TeV (different K-factor)
  m_{gKK}>~1.5 TeV

*FERMILAB-TM-2104



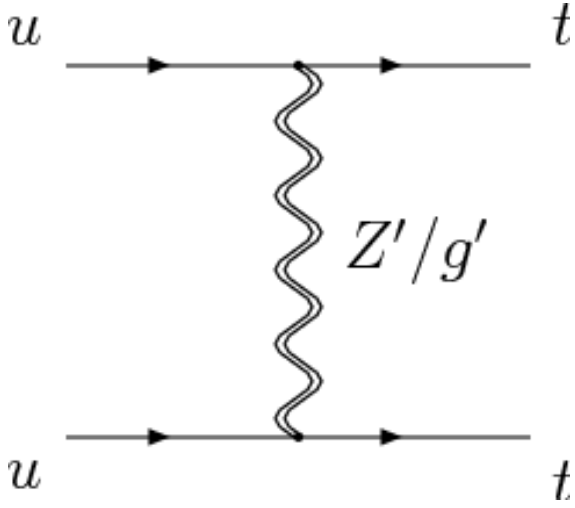


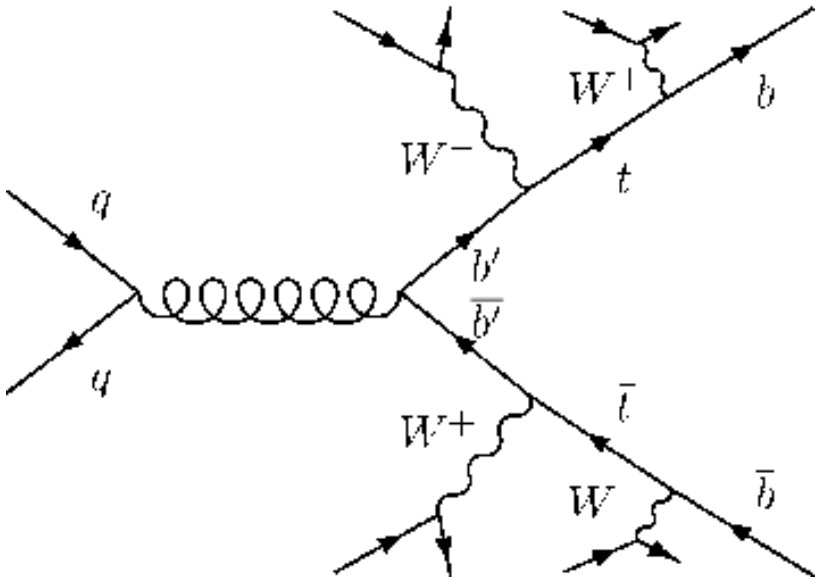
Same-sign top and fourth generation b' quark searches

CERN-PH-EP-2012-020 (1 fb^{-1})

- **Same-sign top** events can help us understand the F/B asymmetry observed at the Tevatron (next slides).
- LEP only fixed the number of *light* neutrinos (to 3). **Fourth family** → heavier Higgs. Chiral down-type –1/3 quark (*b*')

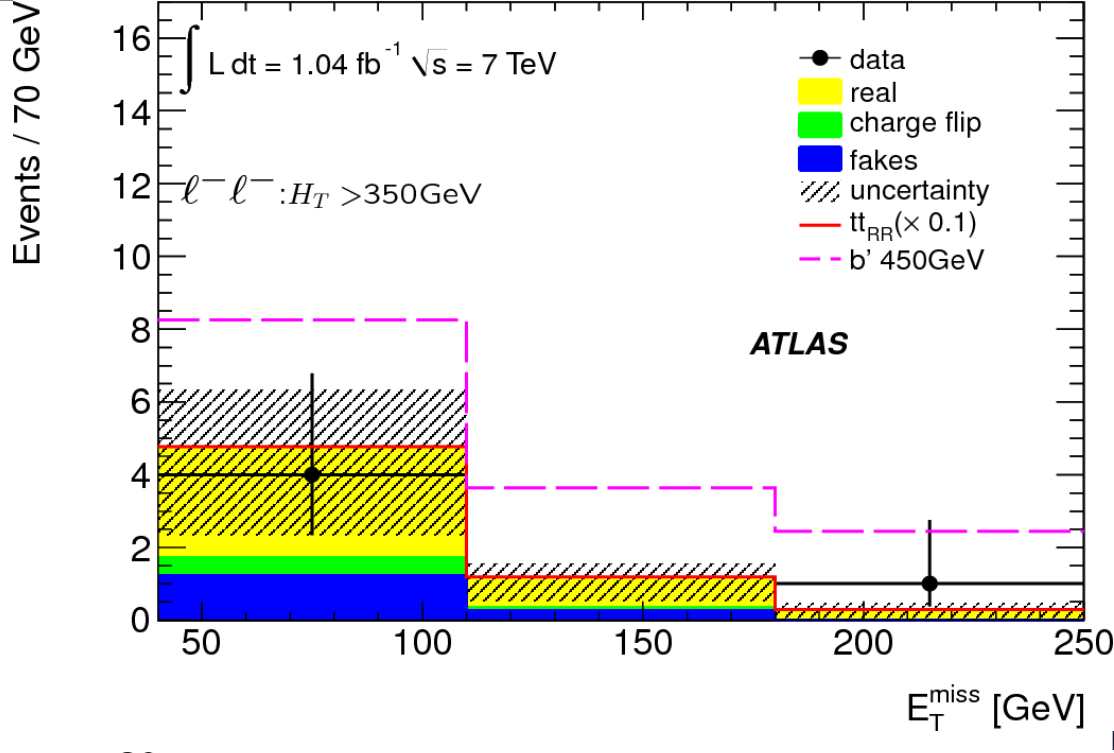
Selection strategy: find *same-sign* leptons

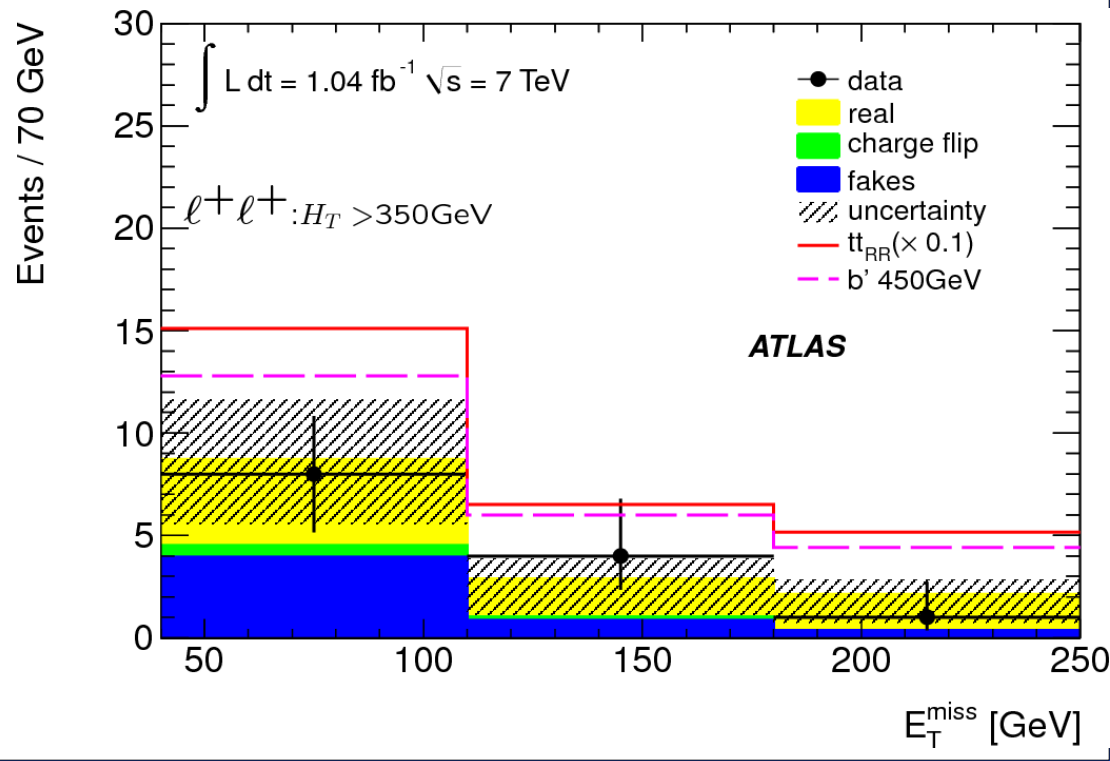




Same-sign top and fourth generation b' quark searches (cont)

- *pp* collider → ++ background more common.
- Event selection:
  - 2 same-sign leptons *ee*, *eμ* or *μμ*
  - 2 jets, E_T^{miss}
  - H_T > 150 or 350 GeV
- "real": true same-sign lepton events from e.g. dibosons
- "charge flip": one misidentified charge
- "fake": misidentified jets or γ

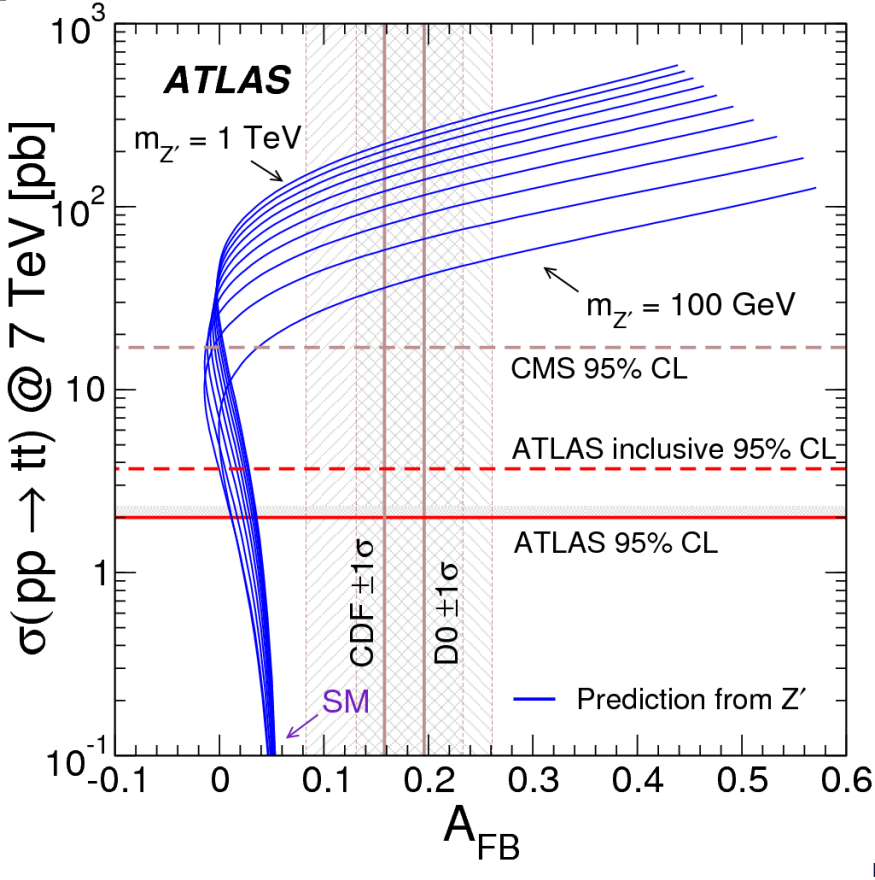


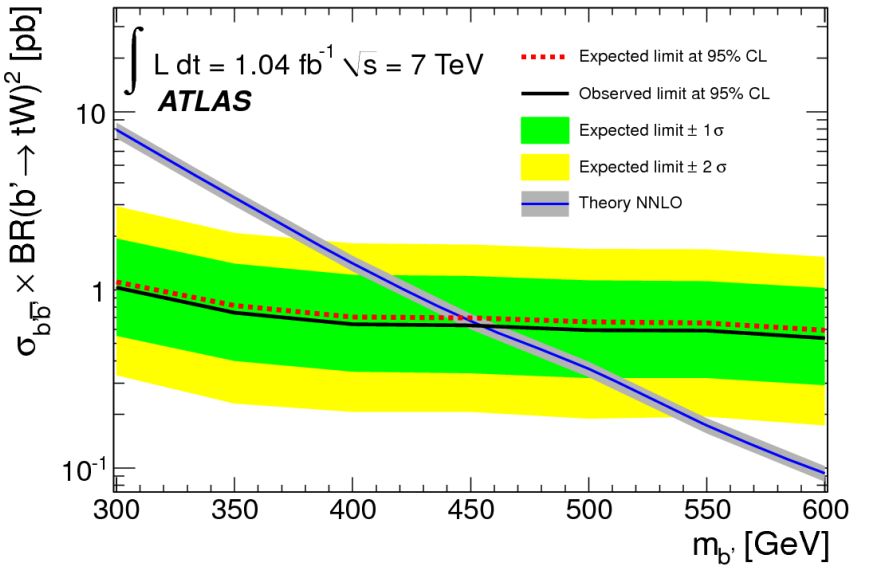


Same-sign top and fourth generation b' quark searches (cont.)

- Upper limits on the tt production with the forward-backward asymmetry from the Tevatron and limits on Z' production.

- 95% confidence level exclusion limits on cross section times branching ratio for $\bar{b}'b'$ production, $b' \rightarrow tW$. $m_{b'} > 450$ GeV
  CLs limits





Future refinement: boosted tops

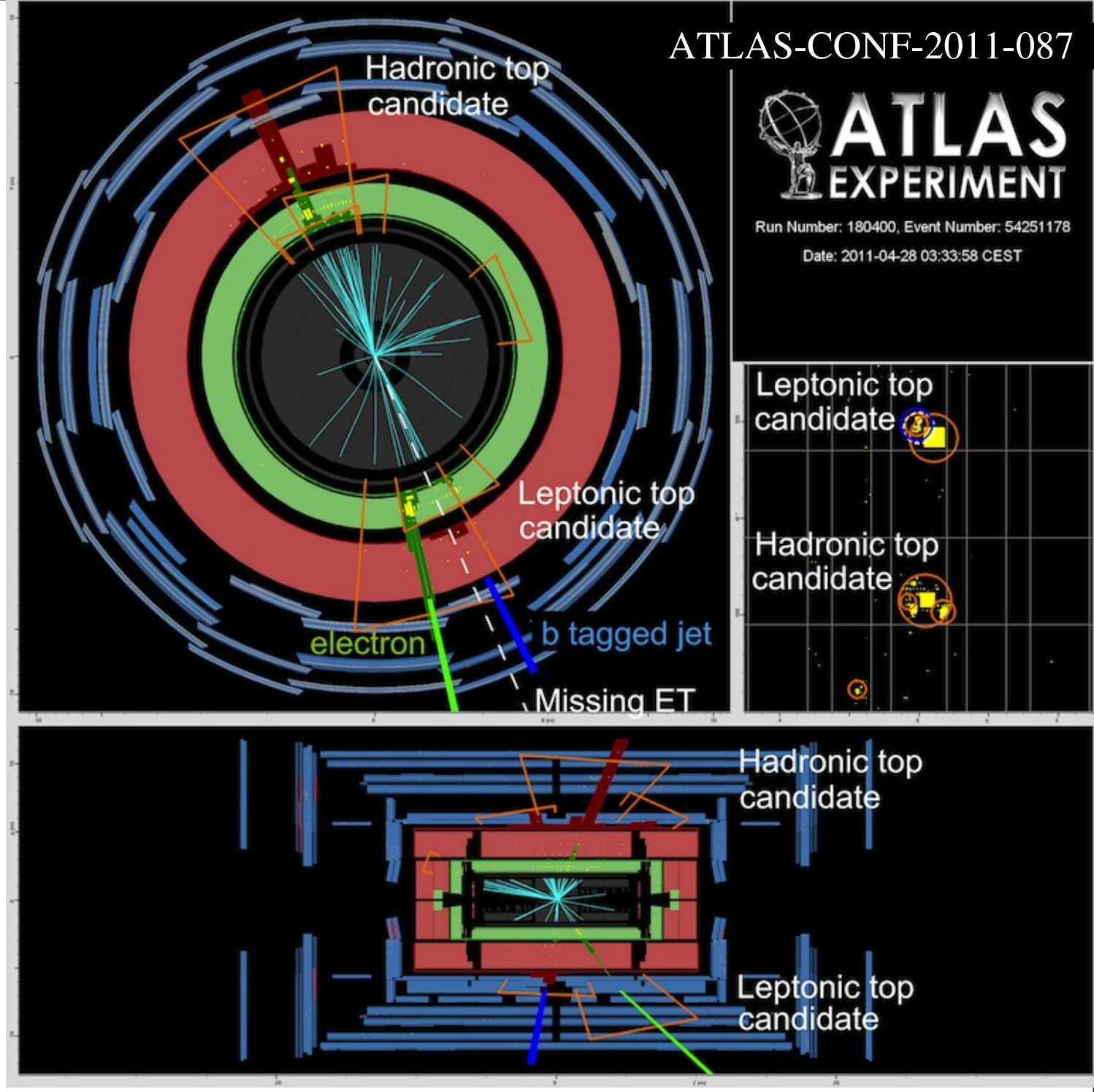
M_{tt} = 1602 GeV

Passes standard top selection.

Alternative approach

Reconstruct the jets with the Anti-k_T R=1.0 algorithm: larger jets capture more of the decay.

Use the properties of these fat jets to "**tag**" the tops.



Thank you!

References

- $t\bar{t}$ cross section measurement in the dilepton channel (0.7 fb^{-1}) – CERN-PH-EP-2011-223
- $t\bar{t}$ cross section – M. Aliev et al “HATHOR” arXiv:1007.1327
- Top cross section combined – ATLAS-CONF-2012-024
- all-hadronic cross section (1 fb^{-1}) – ATLAS-CONF-2011-140
- l+jets cross section (0.7 fb^{-1}) – ATLAS-CONF-2011-121
- Jet multiplicity in ttbar events – ATLAS-CONF-2011-142
- ttbar resonances 2 fb^{-1} – ATLAS-CONF-2012-029
- ttbar resonances 200 pb^{-1} – ATLAS-CONF-2011-087
- BumpHunter tool – G. Choudalakis arXiv:1101.0390
- CMS ttbar resonances – PAS-TOP-11-009
- Bayesian limits – FERMILAB-TM-2104
- Same-sign top and fourth generation *b*' quark searches – CERN-PH-EP-2012-020