Search for New Physics in the tt+MET Final State

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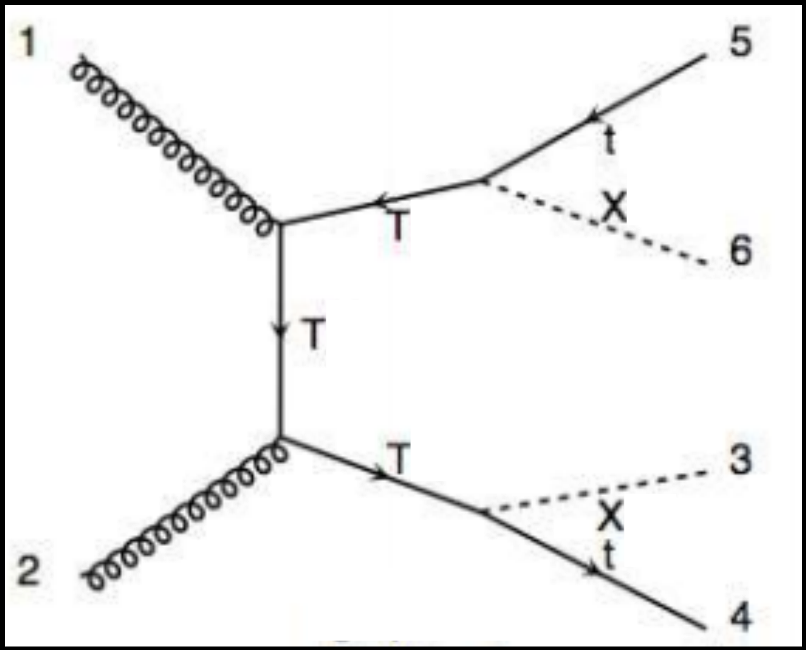
On Behalf of the ATLAS Collaboration



Introduction

- Today will discuss ATLAS's main recent heavy object search
  - A search for new physics in ttbar+MET final state
  - arXiv:1109.4725 (accepted at PRL)

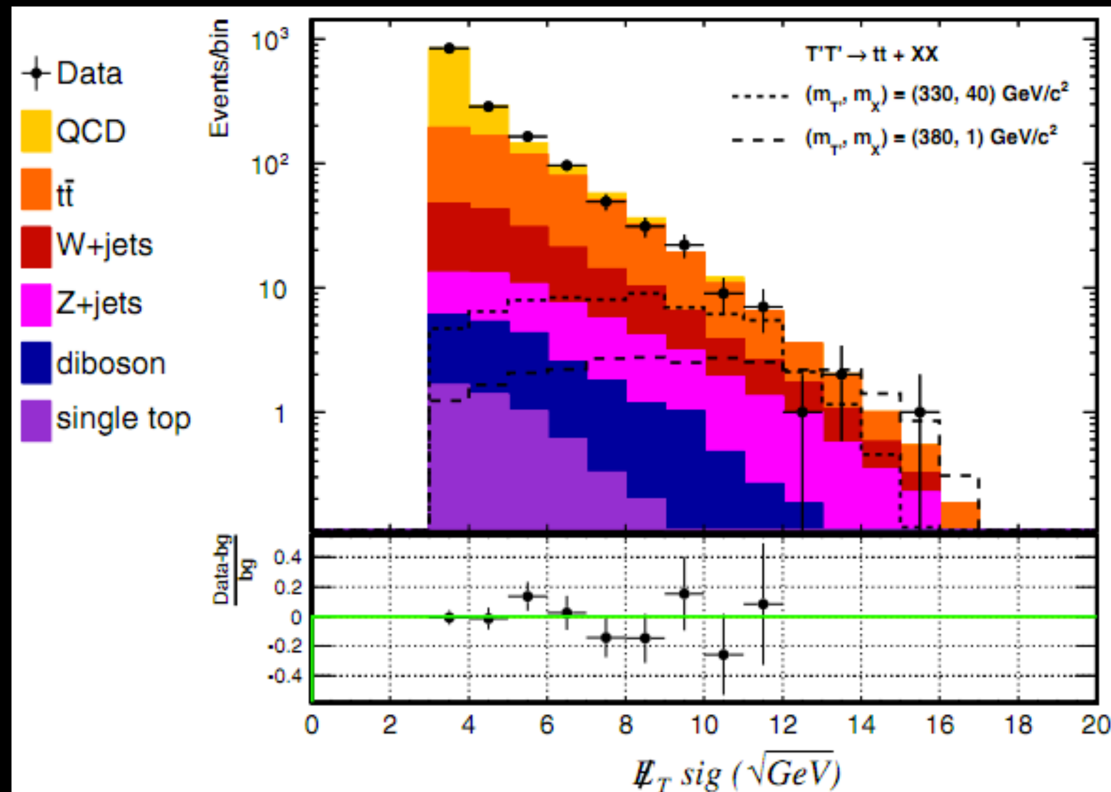
- Many new physics scenarios can produce final states of top's plus missing transverse energy:
  - From SUSY: 2 x stop production
  - 3rd Generation leptonquarks
  - Little Higgs models with T-parity
  - Extra dimensions with KK-parity
  - Others: models of new strong dynamics, etc

Models Continued

- Common features of these models:
  - Expect production of pairs of heavy quarks which decay to tops and a invisible neutral particle
    - Squark => top + gravitino or neutralino in SUSY
    - top plus tau lepton in leptoquarks models
  - Generally search for TT => tAtA where A is invisible
    - A is a dark matter candidate in many models
- Perform inclusive search for new physics in any model
  - Report limits as cross-section x branching ratio for general applicability to different models
  - Main variations between models: spin of particles
    - Spin strongly affects production cross sections, but not dynamics of decay products

Past Work

- CDF One-lepton channel (4.8 fb^{-1}):
  - Phys. Rev. Lett. 106, 191801 (2011)
  - Fit the reconstructed W-transverse mass
- CDF Zero-lepton channel (5.7 fb^{-1}):
  - Phys. Rev. Lett. 107, 191803 (2011)
  - Fit missing transverse energy significance



Fit Results in the 0-lepton Channel at CDF

New Physics Samples are for a dark-matter model with fermion T's and scalar A's

Analysis at ATLAS

- ATLAS analysis with 1 fb^{-1}:

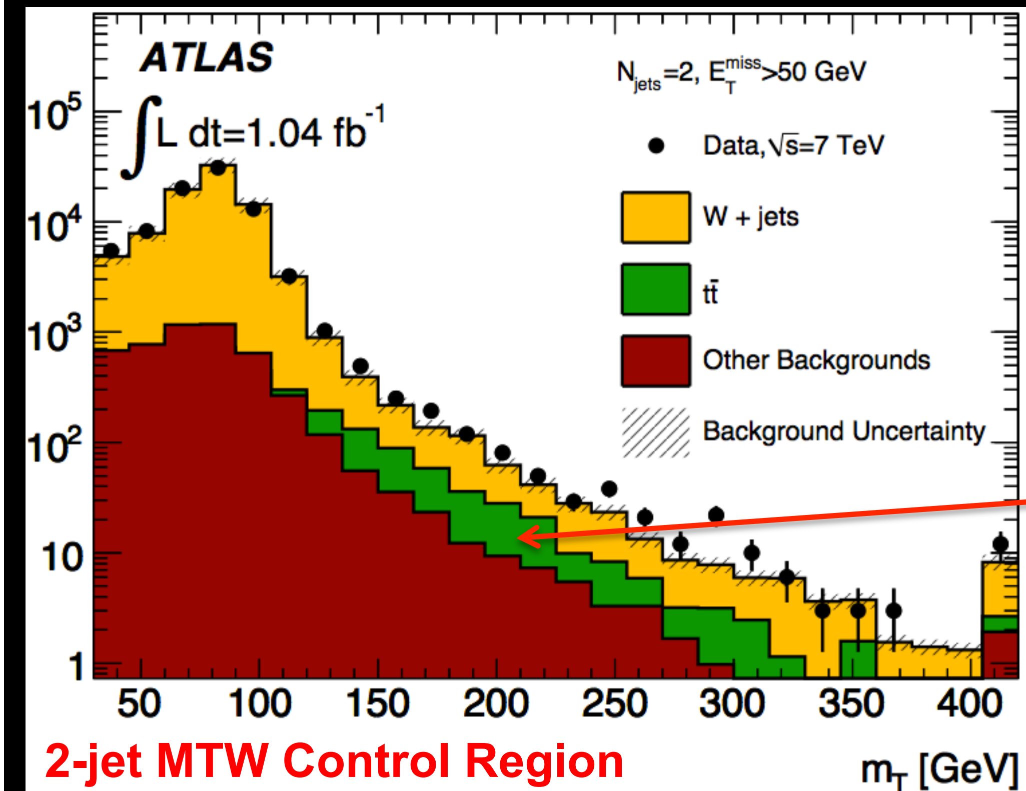
- Analysis in single-lepton channel. Basic selection:
  - Accept events from single-electron or single-muon trigger stream
  - One isolated lepton:
    - Muon with pT > 20 GeV, $|\eta| < 2.5$
    - Or electron with pT > 25 GeV, $|\eta| < 2.4$
    - Both selections are in fully-efficient trigger region
  - Four or more jets reconstructed with pT > 25 GeV, $|\eta| < 2.5$
  - No *b*-tagging – dominant background will be ttbar!

- Perform a straightforward cut-and-count analysis
  - Cuts chosen based upon blinded optimization study given estimated systematics

General Strategy

- ttbar and W+jets are dominant backgrounds
  - ttbar simulated with MC@NLO Monte Carlo
  - W+jets simulated with Alpgen Monte Carlo
  - Samples have lots of real MET, will populate MET tail
- Main handle: reconstruct transverse W-mass between lepton and MET
  - W+jets and single-lepton ttbar: peak near real W-mass, very few events above ~120 GeV
- Cut hard on both MET and transverse W-mass

Dominant Background: 2-lepton



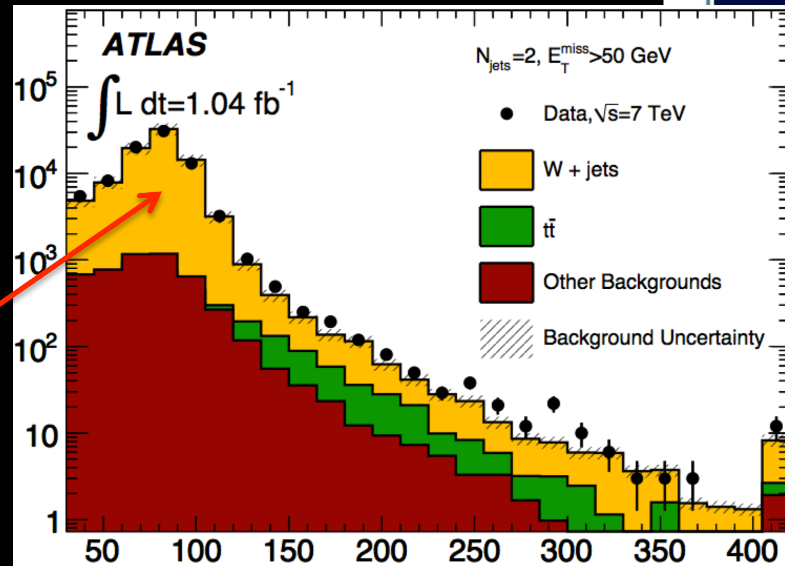
- 2-jet non-*b*-tagged control-region illustration:
  - Events with 1-lepton live under W-mass peak
  - ttbar mostly 2-lepton events
- These events drive unphysical, large W-mass just like signal
  - In signal region with no *b*-tag veto, this is the dominant background

Veto Second Lepton

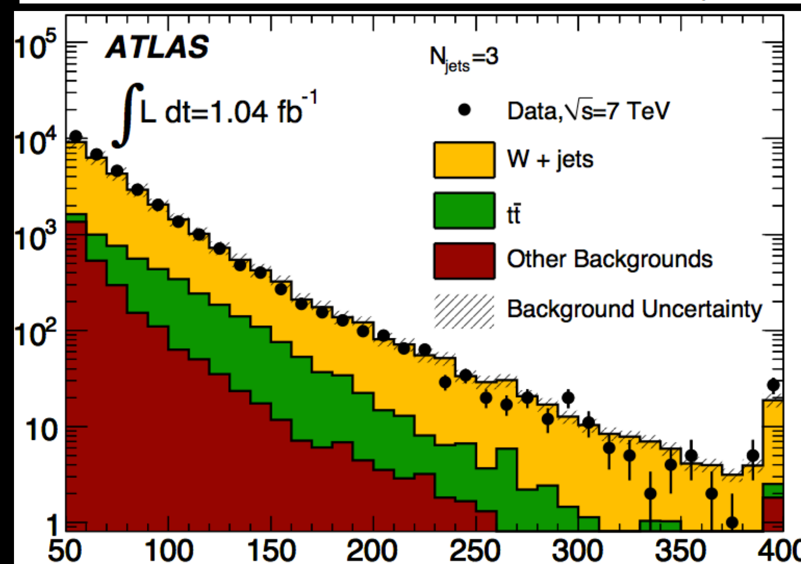
- Make a very tight cut on double-lepton background
  – If any second isolated electron or muon is reconstructed with pT > 15 GeV remove event
- Main case this misses: dilepton events with a tau
  – Also veto events with a second isolated track with pT > 12 GeV: removes most single-prong taus
- Calibration of this veto: measure efficiency in control regions:
  – 2 or 3 jets, no *b*-tag
  – 4-jet, under W-mass peak
  – 2 or 3 jets, high MET: enriches sample in real dilepton events
    - Largest discrepancy between data and simulation in these bins: 10%. Take as systematic uncertainty.

1-Lepton Background

- Calibrate in control region:
  - 1, 2, 3, or >=4 jets, no b-tags
  - Very little signal survives
  - Normalize simulation under W-mass peak
    - -5 +/- 3 % Correction
  - Will correct simulation in signal region according to tail
- Control region depletes ttbar
  - But ok because single-lepton ttbar and W+jets have ~identical transverse mass distributions

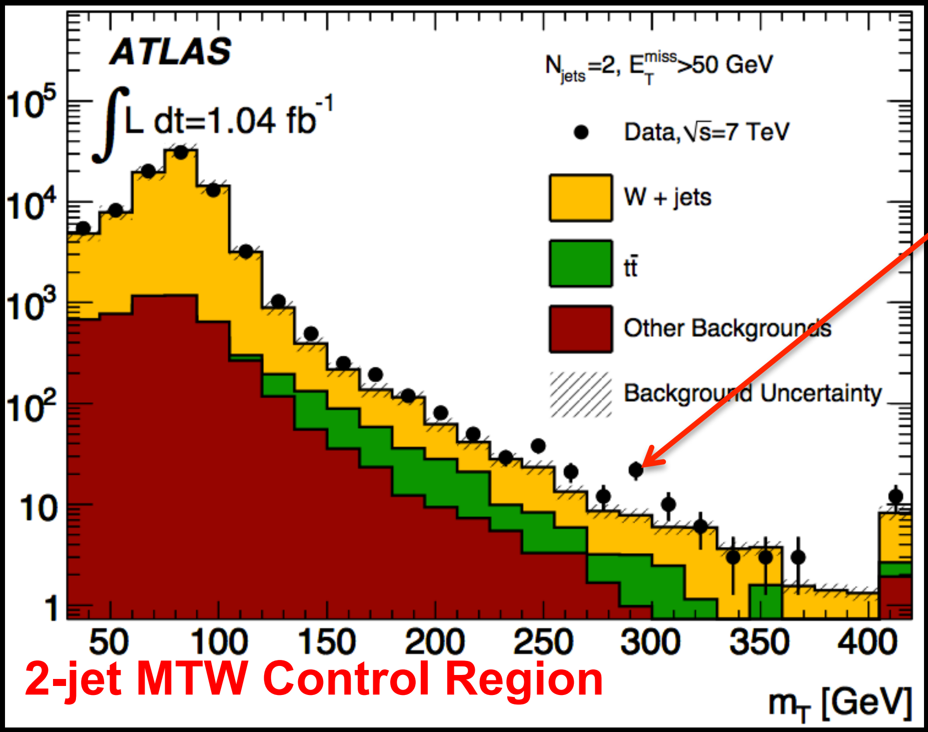


2-jet MTW Control Region



3-jet MET Control Region

Corrections from Control-Region



- In all four control regions observe that high-MTW tail is underestimated
  - Simulate tail in signal region, correct 1-lepton contribution by +15% +/- 10% (uncertainty from spread in control regions)

Multijet Background

- All Multijet backgrounds taken from data
- Fake electrons from multijets:
  - Two different models of fake electrons with inverted selection criteria
    - Fit to MET distribution in high-isolation region
    - 100% normalization uncertainty from worst-case control-region studies
    - Cross-checks between different anti-electron models consistent
- Fake muons from multijets:
  - Found to be negligible from matrix-method estimation
  - Low stats conclusion, but cross-checked in (a) lower-jet multiplicity bins and (b) with looser MET cuts and a projection to signal region using anti-electron shapes
    - All results consistent with 0

Systematic Uncertainties

- Dilepton ttbar + other small backgrounds (diboson, single-top): Largest uncertainties from
  - Top cross-section, jet energy scale, dilepton veto efficiency
  - Total: 23%

- Single-lepton backgrounds:
  - MTW calibration is dominant uncertainty. MTW peak normalization also significant.
  - Total: 11%

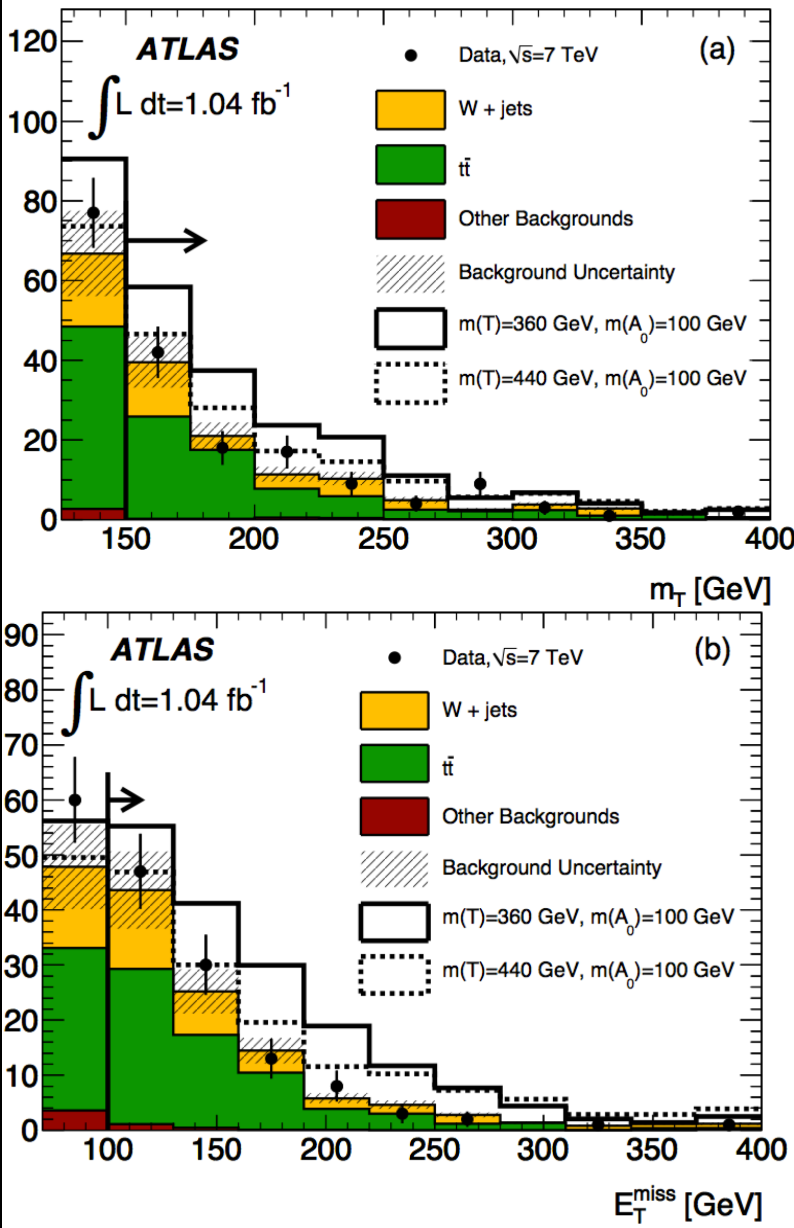
- Signal uncertainties:
  - Theory cross-section, I/FSR, jet energy uncertainties dominate
  - Total: 15%

Resulting Distributions

- Final distributions shown
  - Cuts chosen to right of the black lines
  - No statistically significant excess observed

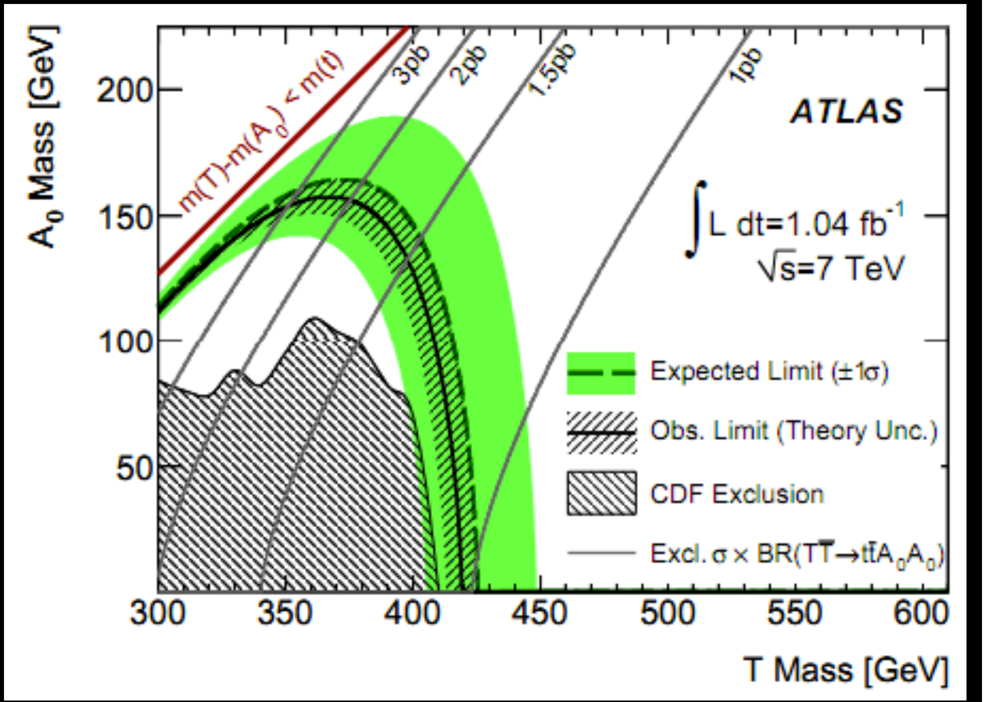
Source	Number of events
Dilepton $t\bar{t}$	62 ± 15
Single-lepton $t\bar{t}/W$+jets	33.1 ± 3.8
Multi-jet	1.2 ± 1.2
Single top	3.5 ± 0.8
Z+jets	0.9 ± 0.3
Dibosons	0.9 ± 0.2
Total	101 ± 16
Data	105

Predicted and Observed Events



Setting Limits

- Limits set using frequentist confidence intervals
  - Systematics assumed gaussian with proper Signal and Background correlations

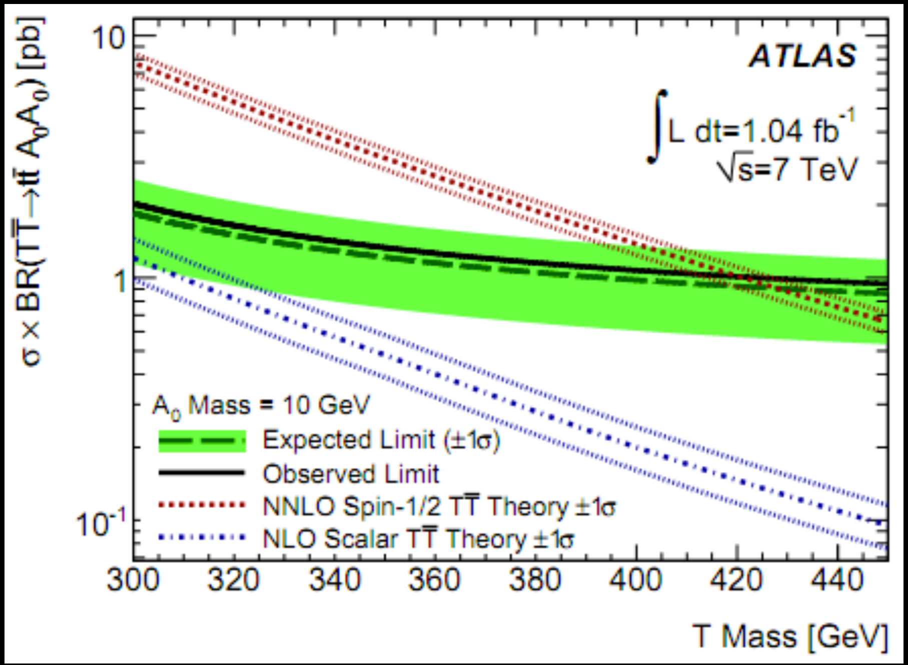


95% Exclusion limits for ATLAS and CDF

Note that at diagonal mT = mA + mt line analysis becomes *very* tough because signal is ~degenerate with standard model ttbar

Future Work

- Heavy scalar models have ~6 times smaller cross-section
  - Examples: stop quarks, leptoquarks, etc
  - Acceptances same as fermionic models so cross-section limits same within uncertainties
  - But improved stats/analysis needed to exclude them
- Eventually small backgrounds such as tt+Z will become important



Cannot yet exclude scalar quark models in this analysis

Conclusion

- Have shown overview of ATLAS tt+MET analysis
  - Current best limits on dark-matter tt+MET model
  - Update of analysis will be needed to push limits and set first limits for scalar particles

- Other analysis channels will also be pursued to maximize sensitivity