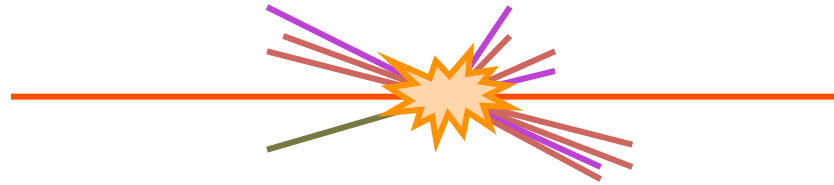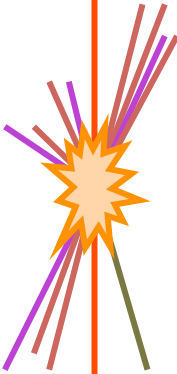# ATLAS: top physics

G. Barone, **W. H. Bell**, V. Dao, C. Doglioni,
J. Erdmann, G. Pásztor, S. Gonzalez Sevilla,
A. Lister, S. Nektarijević, K. Rosbach, I. Watson

Overview

- Introduction
- Inclusive top quark production cross-section
- Top quark production as a function of jet multiplicity
- Search for fourth generation top-like quark
- Top quark production with an associated photon
- Pseudo-top quark as a function of p_{T}
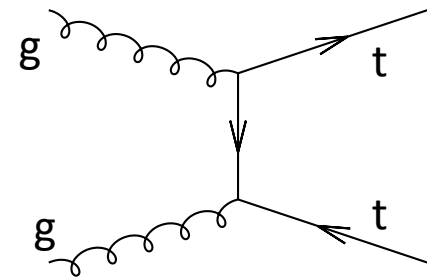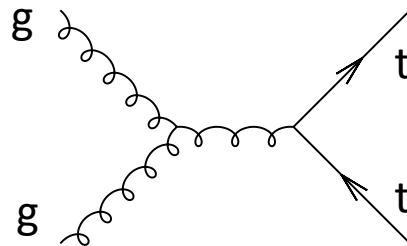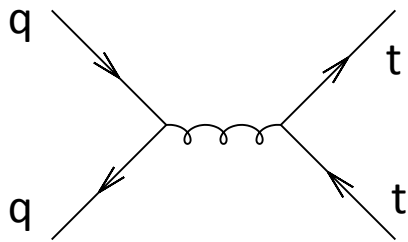- Boosted top quarks
- Conclusion

The top quark

- The heaviest fundamental particle observed.
  - Expect large coupling to the mediator of electroweak symmetry breaking.
  - Possible new physics may couple to the top quark.
- LHC is a top factory.
  - Production cross-section 20 times higher than at the Tevatron.
    - Geneva involved in 1995 discovery at Tevatron
  - Allows detailed studies of:
    - top properties
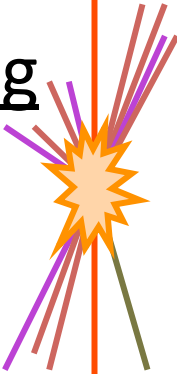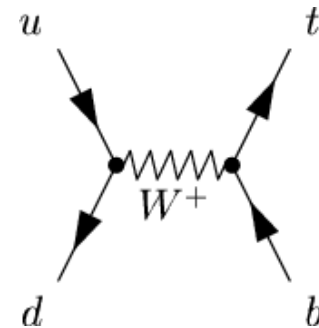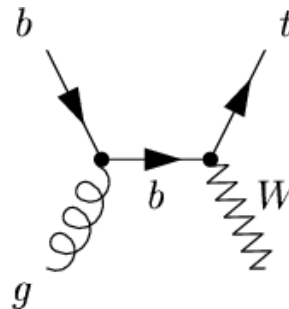   - searches for new physics processes.
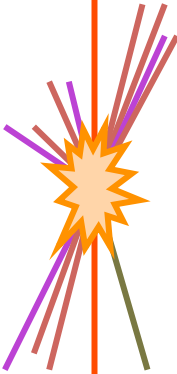
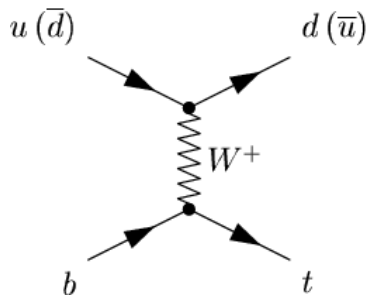# Top quark production
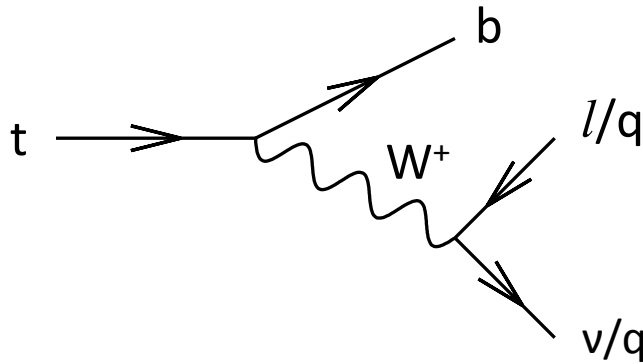
- <u>Dominant production through flavour conserving strong coupling.</u>

- Single quark production through electroweak coupling.
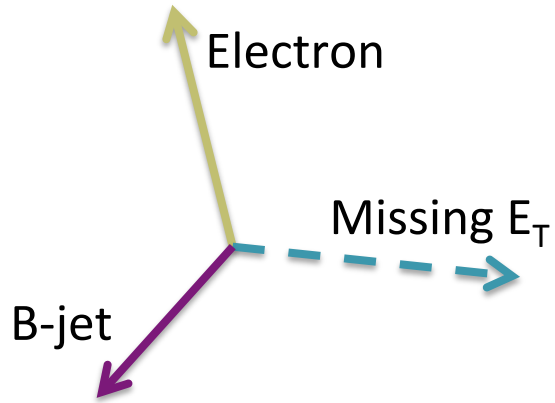
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Top quark identification

- Three categories of decay
  - All hadronic, single lepton and dilepton.
- Single-lepton channel selected using a high p_T inclusive single lepton trigger (electron or muon)

Single-lepton event selection

Electron

Missing E_T

B-jet

At least three or four jets reconstructed with the anti-k_t algorithm (0.4 radius parameter)

Missing energy vector from calorimeter energy deposits and muon term.

ATLAS EXPERIMENT

Run Number: 159086, Event Number: 64558586
Date: 2010−07−14 15:04:51 CEST

35 ET (GeV)

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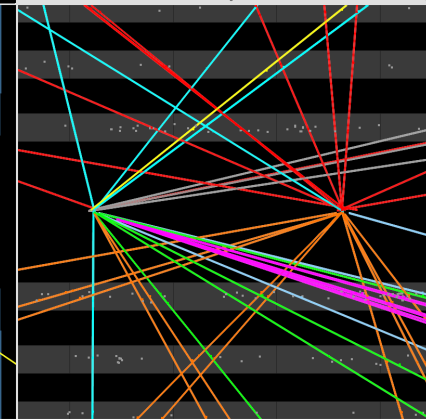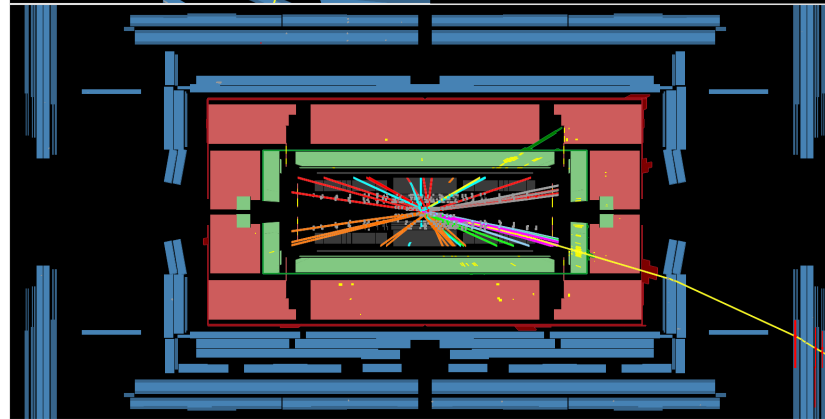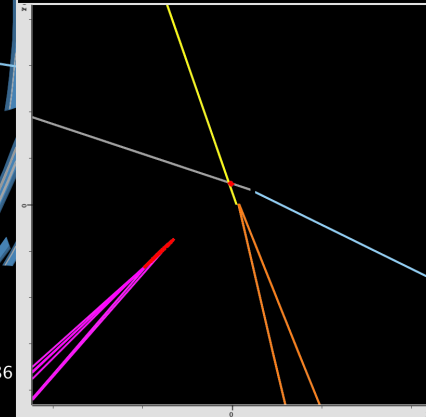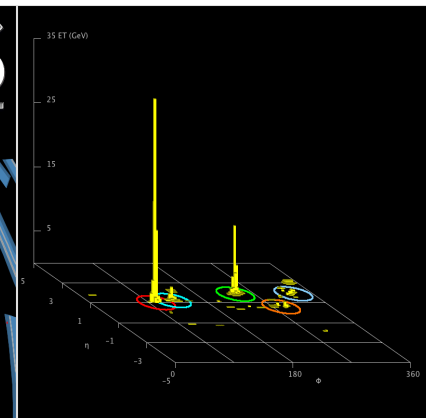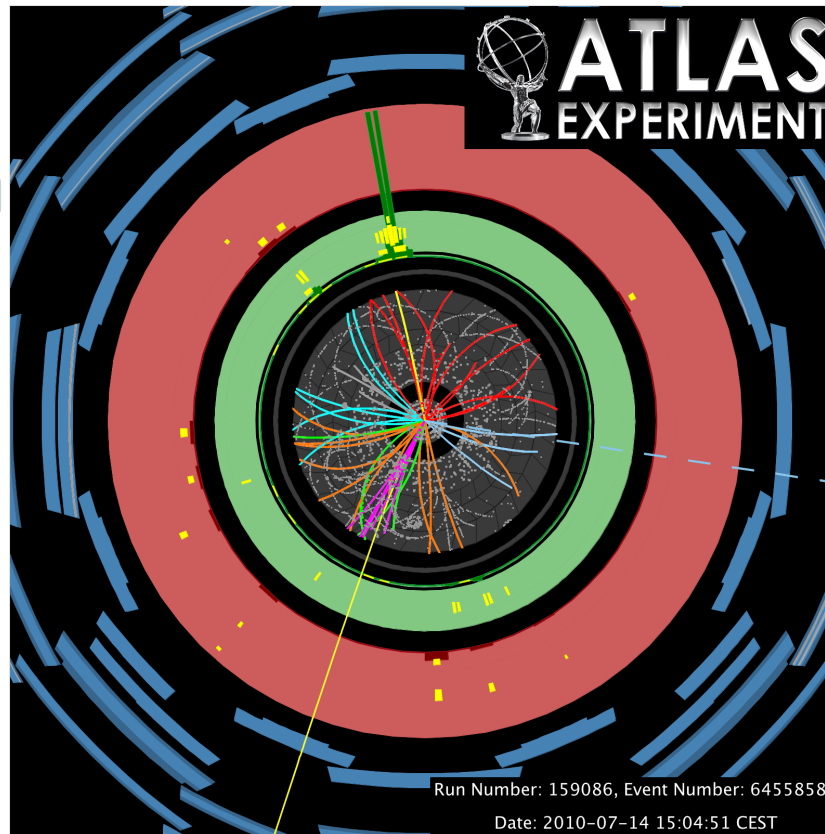
Inclusive top anti-top cross-section

- Geneva joined ATLAS top physics working group in 2010.
- W. H. Bell, V. Dao, A. Lister and I. Watson performed an inclusive top anti-top pair production cross-section measurement
  - Based on data taken during the 2010 proton-proton running period.
  - Single-lepton channel without b-tag requirement.
  - Genetic algorithm used to optimise event selection, including main sources of systematic uncertainties.
  - Used as cross-check of final ATLAS result.

Inclusive top anti-top cross-section
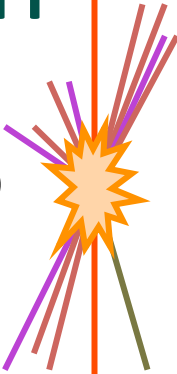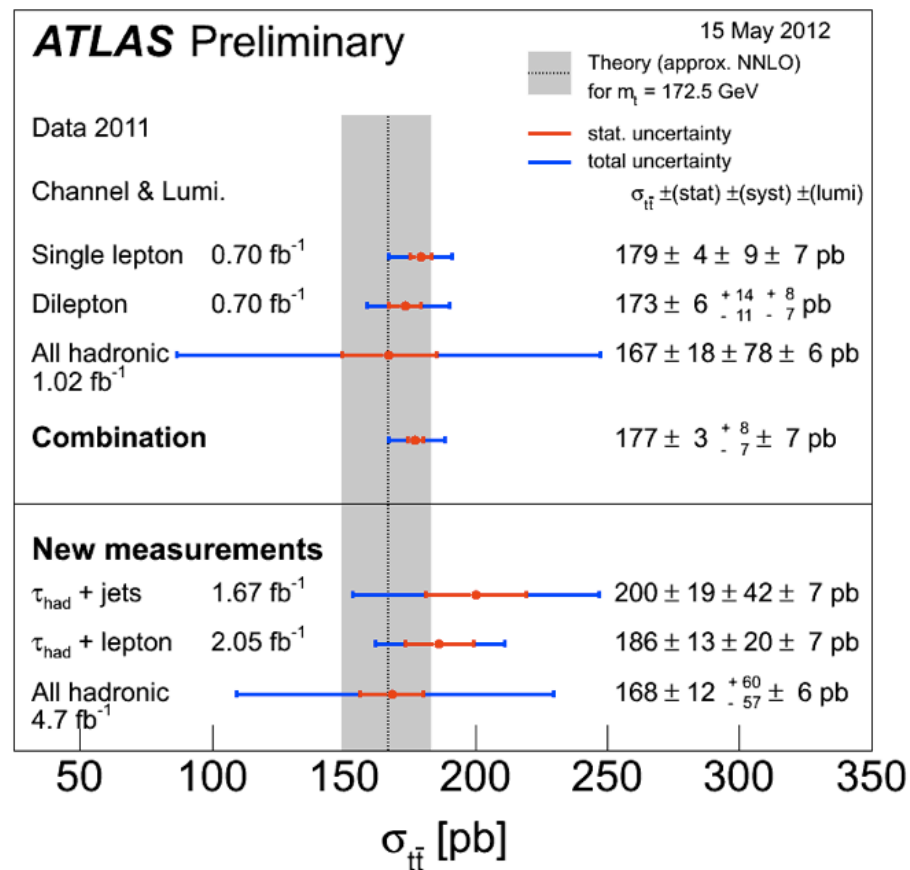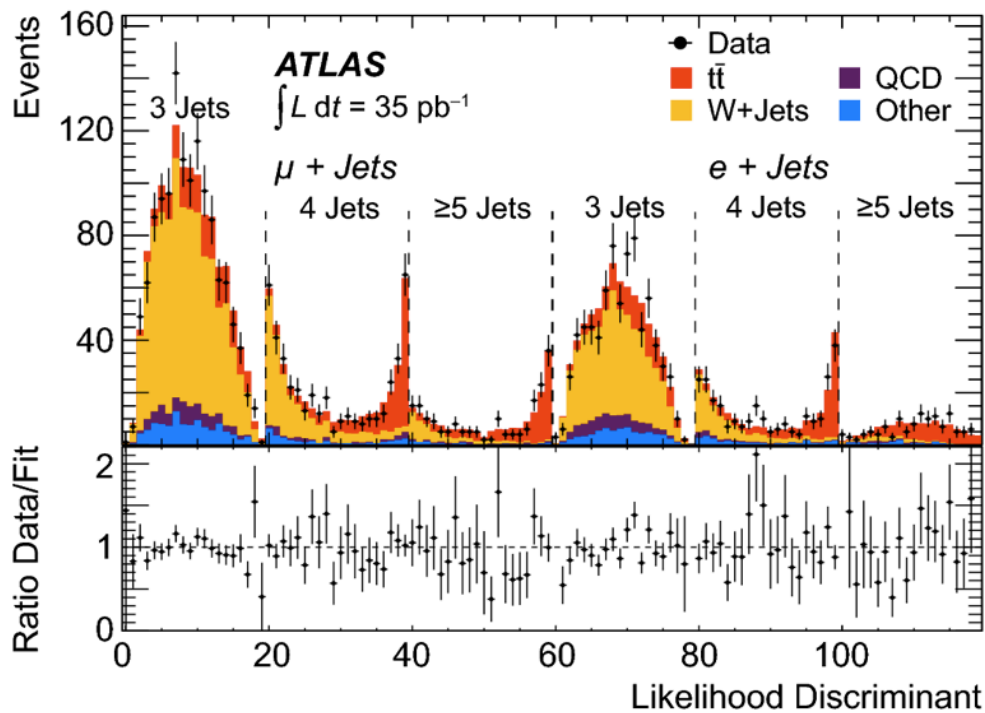
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/TopPublicResults
Measurement of the top quark pair production cross-section in the single lepton channel

Cross-section f(jet multiplicity)

- V. Dao and W. H. Bell preformed a first measurement of jet multiplicity in the single-lepton channel

  - Several different jet transverse momentum thresholds to sample additional radiation

- W. H. Bell now performing analysis with full 2011 data set (5fb^{-1}).

  - Unfolded within kinematic range corresponding to acceptance of event selection.

Cross-section f(jet multiplicity)

https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2011-142/
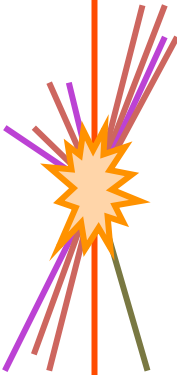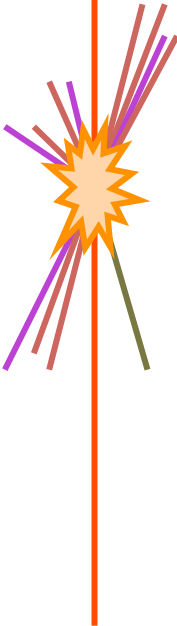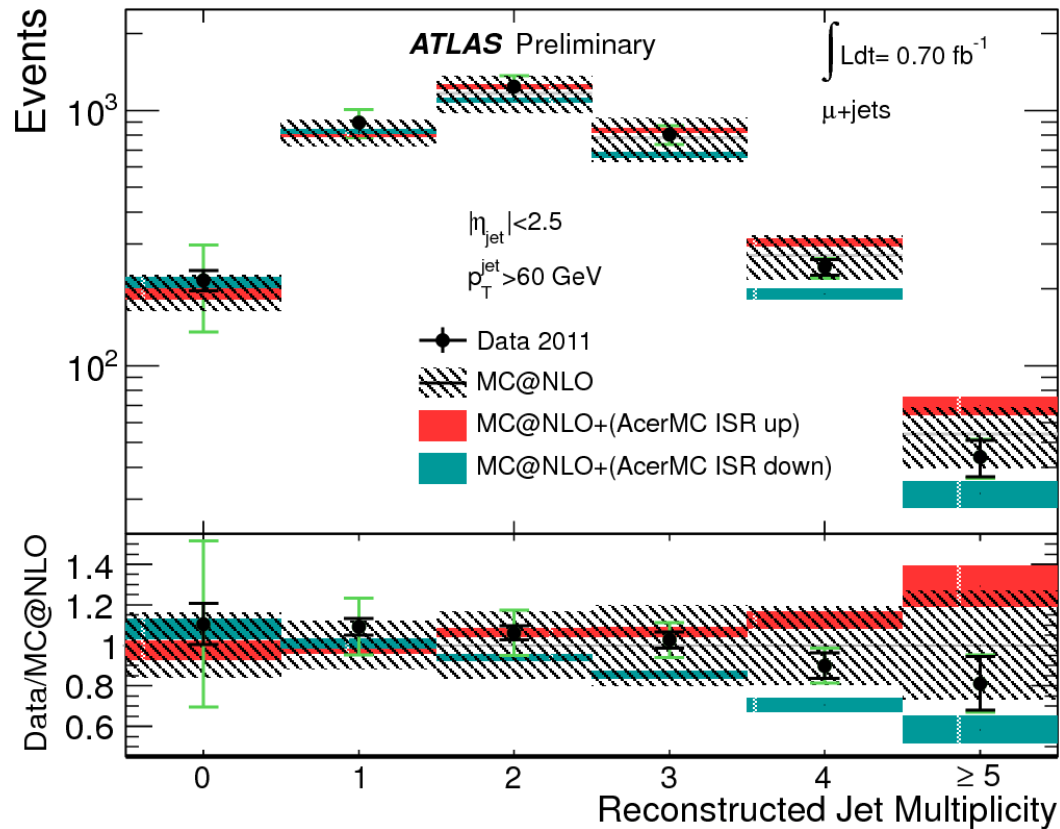
"Reconstructed jet multiplicities from the top-quark pair decays and associated jets in pp collisions at √s = 7 TeV measured with the ATLAS detector at the LHC"

Fourth generation top-like quark

- EW precision data allows for additional generations.
  - Presence of fourth generation would provide further insight into mass mass hierarchy problem, top-pair forward backward asymmetry, and Higgs boson predictions.
- A. Lister and S. Nektarijević searched for the presence of a fourth generation top-like quark in the single-lepton channel.
  - Set an upper limit of $m_{t'}$>404 GeV for the mass of the fourth generation quark at the 95% confidence level.
- A. Lister and S. Nektarijević performing an updated search using full 2011 data set (5fb^{-1}).
  - Understanding the difference between neural network and cut based approach.
  - Follow result to its publication.
- A. Lister and S. Nektarijević plan to improve this analysis and take a leading role in the study of the 2012 data set.

Fourth generation top-like quark
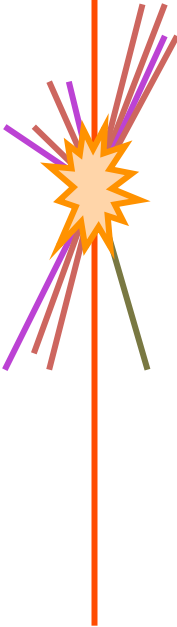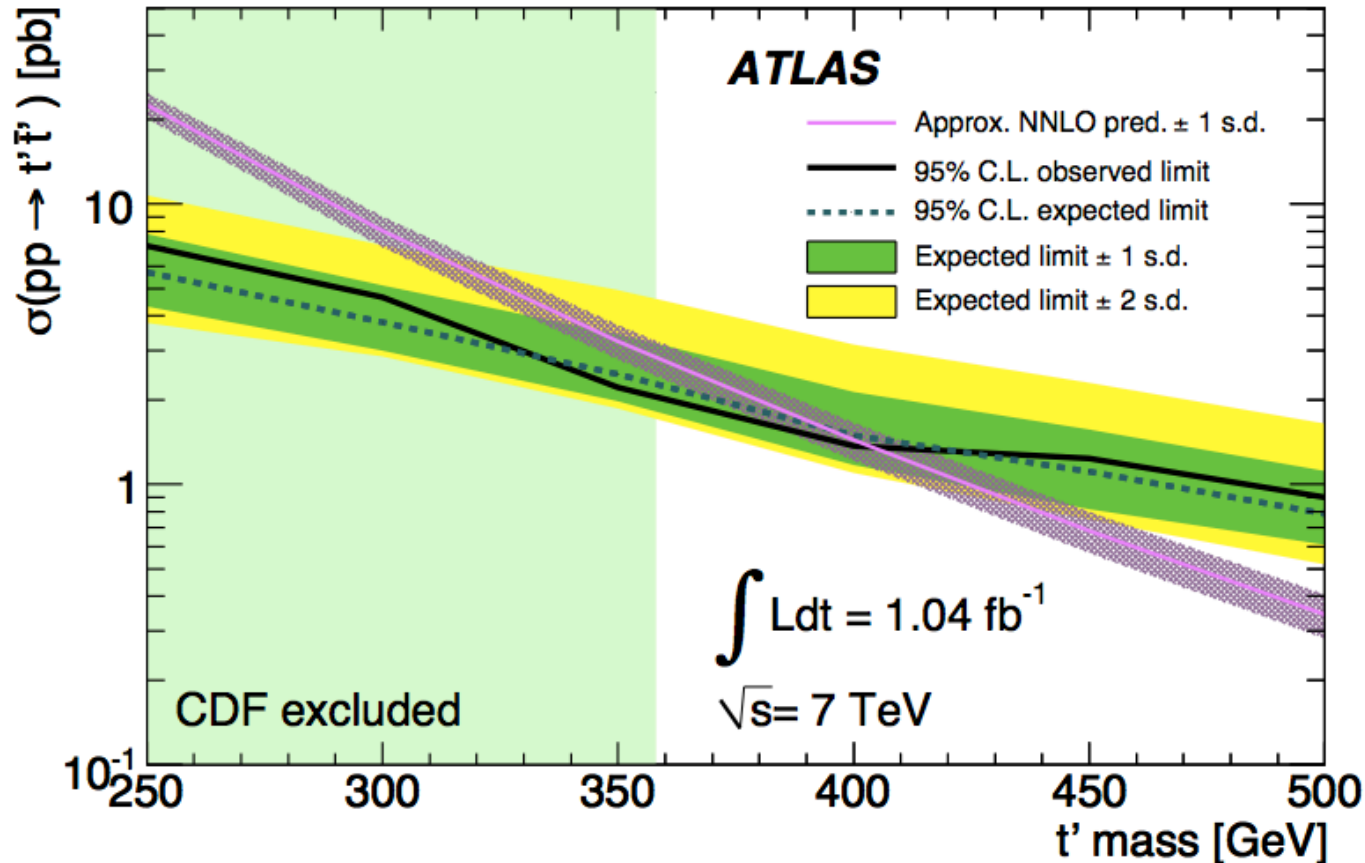
"Search for Pair Production of a Heavy Quark Decaying to a W Boson and a b Quark in the Lepton+Jets Channel with the ATLAS Detector"

Cross-section f(pseudo-top p_T)

- W. H. Bell and I. Watson performing unfolded pseudo-top p_T measurement using 2011 data (5fb^{-1}).
  - Pseudo-top defined from recipe rather than kinematic fitter
    - Avoid Monte Carlo generator dependence.
    - Compare fixed order pQCD calculation with parton shower, within the kinematic range of the result.
  - Define observable with particles and reconstructed objects.
    - Unfold from reconstructed observable to particle observable.
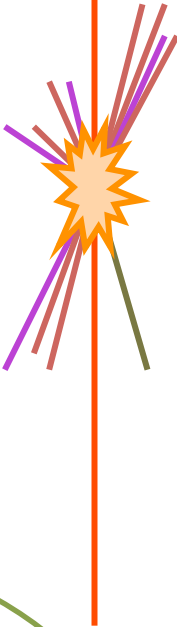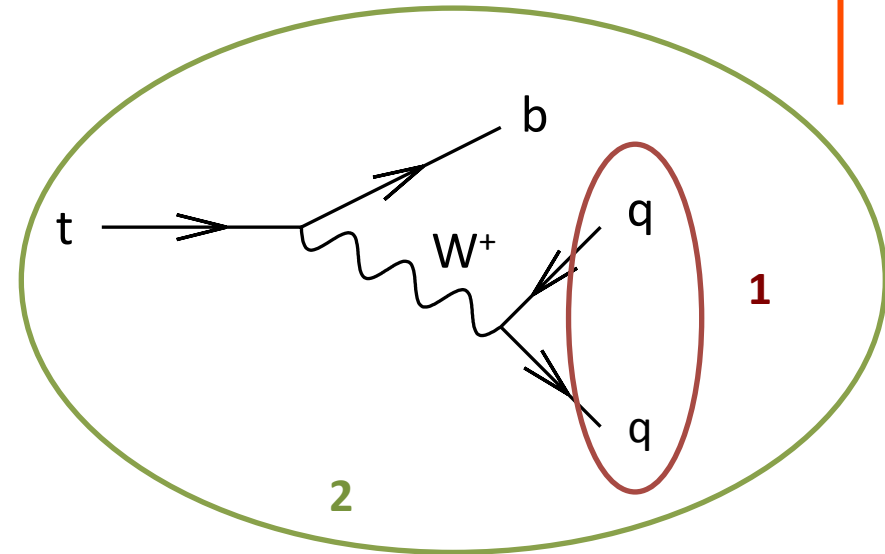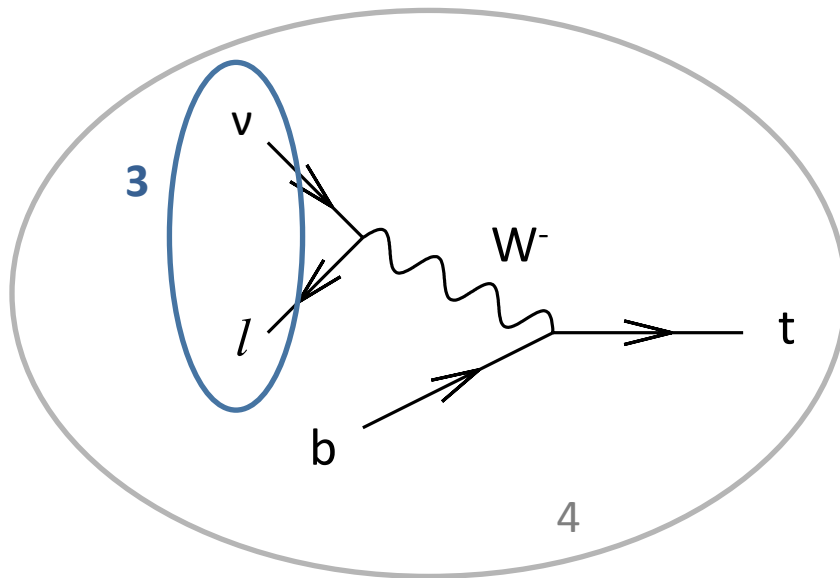
Cross-section f(photon E_T)

- S. Gonzalez Sevilla and G. Barone are performing a cross-section measurement for top anti-top events which contain additional photon.
  - Constrain top charge and test SM using ttbar+gamma/ttbar.
  - Analysis is being performed using 2011 data set (5fb^{-1})
  - Plan to perform a differential analysis with 2012 data.
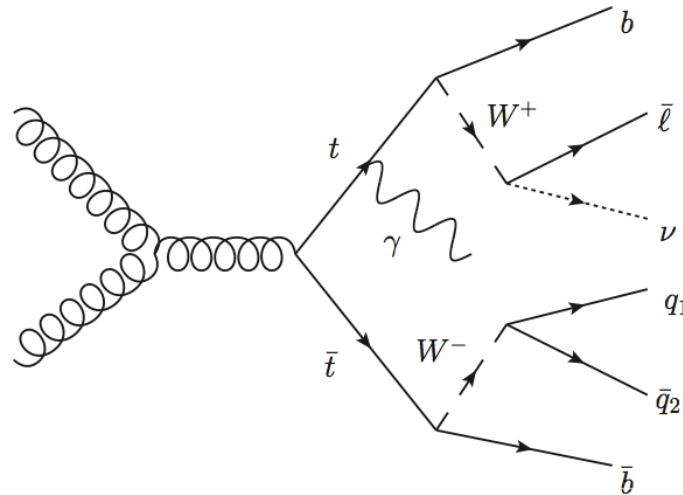
- G. Pásztor editorial board member for this analysis and ttZ production.
  - Improvements to ttZ analysis, signal and background selection.
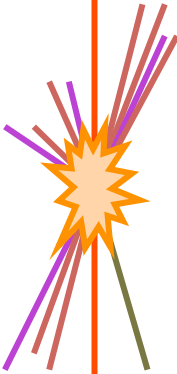
Reconstructed objects, jet performance and backgrounds

- A. Lister is coordinating the selection of reconstructed objects within the ATLAS top working group.

- C. Doglioni is coordinating detailed studies of jet reconstruction for top analyses within the ATLAS top working group.
  - Studies performed by C. Doglioni, F. Guescini and A. Picazio, et al.

- K. Rosbach has carried out detailed studies of ETmiss and recently performed a QCD-multijet background estimate for the single-electron final state.

Boosted top properties

- J. Erdmann plans to carry out a study of boosted top kinematics.

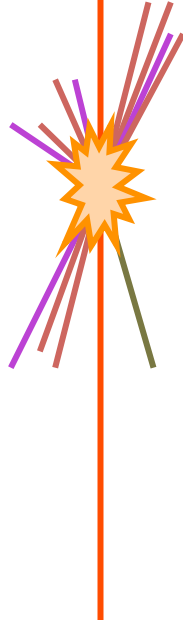 – Search for new physics within the ttbar invariant mass tail (0.5 < m(ttbar) < 2TeV).

  – Reconstructed objects become fat jets (R=1).

    - Require grooming algorithms for event reconstruction.

Boosted top properties

b-tagged jet

leptonic top candidate

missing E_T

Electron

hadronic top candidate

leptonic top candidate

hadronic top candidate
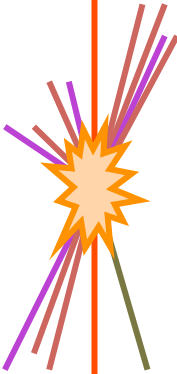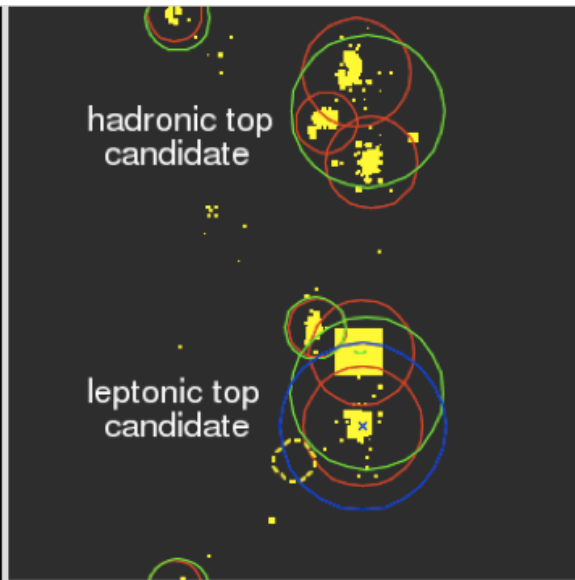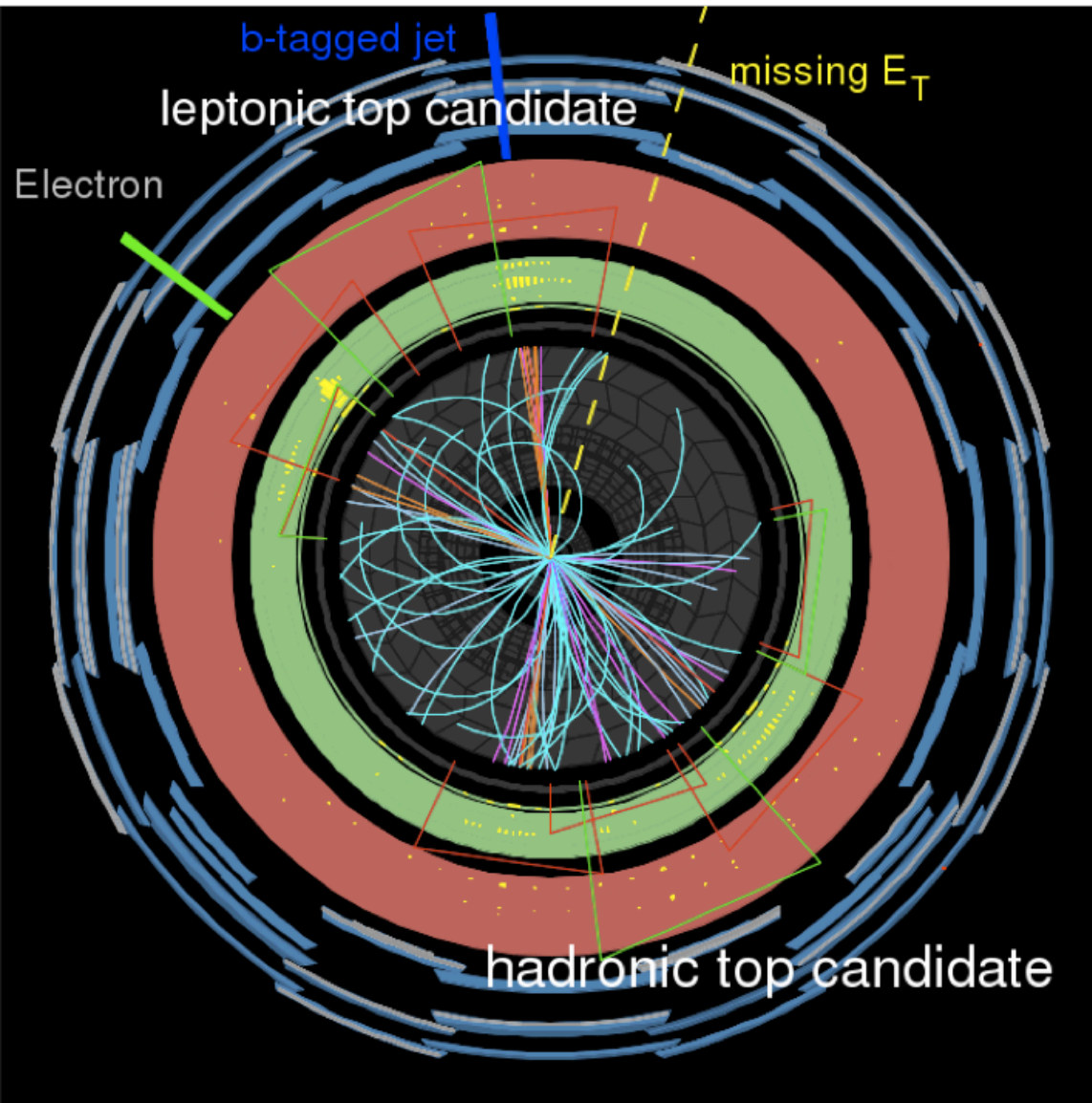
ATLAS EXPERIMENT

Run Number: 166658, Event Number: 34533931

Date: 2010-10-11 23:57:42 CEST

Conclusions

- The Geneva group has carried out several analyses within the top group.

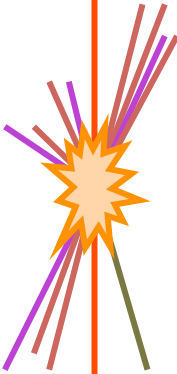- Analyses of the 2011 data taking period ($5fb^{-1}$) are nearing completion.

- Fourth generation search and studies of boosted top quarks planned for 2012 data set ($\sqrt{s} = 8TeV$, $15fb^{-1}$).

- The DPNC computing cluster managed by S. Gadomski and Y. Meunier has been and continues to be a vital resource for these analyses.

Typical single-lepton event selection

- Exactly one lepton (muon or electron) passing identification and isolation requirements
  - p_T > 20 or 25GeV, $|\eta|$<2.5
- Missing transverse energy reconstructed from vector sum of calorimeter energy, after weighting according to associated reconstructed objects.
  - ETmiss > 30 GeV
- Transverse W mass reconstructed from ETmiss and lepton

$$m_T = \sqrt{2\, p_T^\ell\, E_T^{\mathrm{miss}}\, (1 - \cos\Delta\phi)}$$

  - ETmiss + m_T > 60 or m_T > 30GeV
- Jets reconstructed with anti-kt algorithm (0.4 radius parameter)
  - p_T > 25 GeV
- Jets containing B-hadron decay products identified through combination with lifetime information from associated tracks.
  - One or more b-tagged jet. ("tagged")