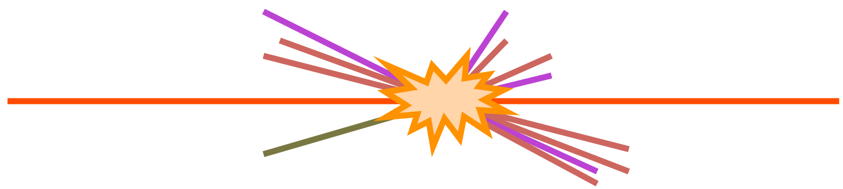
Common top (pair) acceptance: definitions



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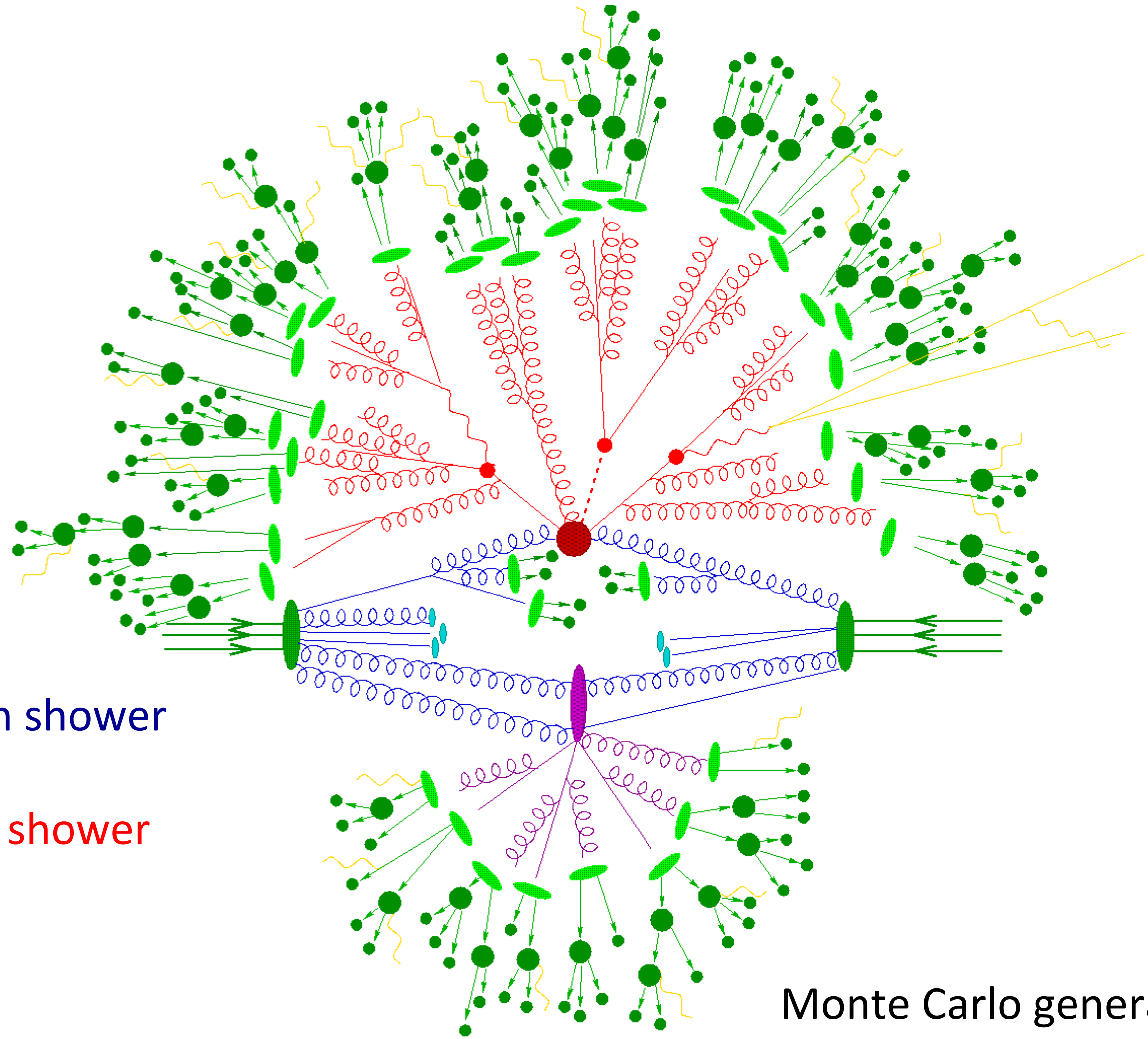
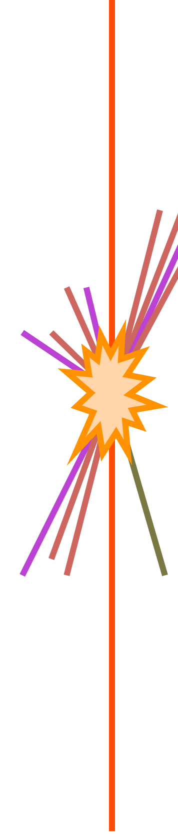
On behalf of the ATLAS collaboration

Overview

- Motivation
- Object definitions
- Pseudo-top definitions
- Conclusions and outlook

A proton-proton collision





Initial state parton shower
Signal process
Final state parton shower
Fragmentation
Hadron decays
Beam remnants
Underlying event

Monte Carlo generator representation
Sherpa

Previous measurements

- Measurements have been traditionally presented with extrapolations to $p_T = 0$ and 4π sr.
  – Integrate over MC, in regions where no data/MC comparisons exist.
  – May wash out possible data/MC disagreement in measured region.
- Kinematic fitters have been used to extract a top signal.
  – These fitters are based on transfer functions derived from MC simulations.
- Warning:
  – MC generators include many pieces which are phenomenological models and may be improved over time.
    - Colour reconnection with the beam remnant.
    - Fragmentation and hadronisation.
    - Underlying event.

Fiducial measurements

- Correct for detector effects and present measurements in terms of stable particles ($\tau > 0.3 \times 10^{-10}$ s) from a single *pp* interaction.
  – After hadronisation, including all phenomenological effects.
- Define acceptance in terms of objects constructed from stable particles.
  – Improve parton-level measurements by using the observed kinematic region.
  – Define templates for kinematic fits within acceptance.
- Define observables in terms of these objects.
  – Unfolding and correcting for detector effects only.
  – Tables of data to HEPDATA and analysis in RIVET.
- Add extrapolation of results as a final comment, but not as the main measurement.
  – This is a convenience to the theoretical community and should not be used to constrain models.

Particles objects: initial definitions

- Define objects from stable particles ($\tau > 0.3 \times 10^{-10}$ s).
  - Match reconstructed object definitions as closely as possible.
  - Objects required to be within observed pseudorapidity range.
- **Jets**: anti-k_t jets of stable particles with radius parameter 0.4.
  - Two selections in use: with and without neutrinos.
- **Electrons**: stable electron and four-vector sum with photons within a cone of 0.1
  - Isolation requirement OR match to W boson decay (including tau decays).
- **Muons**: stable muon.
  - Isolation requirement OR match to W boson decay (including tau decays).
- **E_T^{Miss}**: four-vector sum of stable neutrinos
  - Then use the transverse component and azimuth.
  - W boson match (including tau decays) OR inclusive.
- **B-tag**: re-cluster the jet including B-hadrons with $p_T \approx 0$ OR one or more b-hadrons within a cone of 0.3 of the jet.
  - p_T requirement on B-hadron to improve correlations.
- Remove jets which are electrons, using $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$ matching similar to reconstructed objects.

CMS and ATLAS common definitions

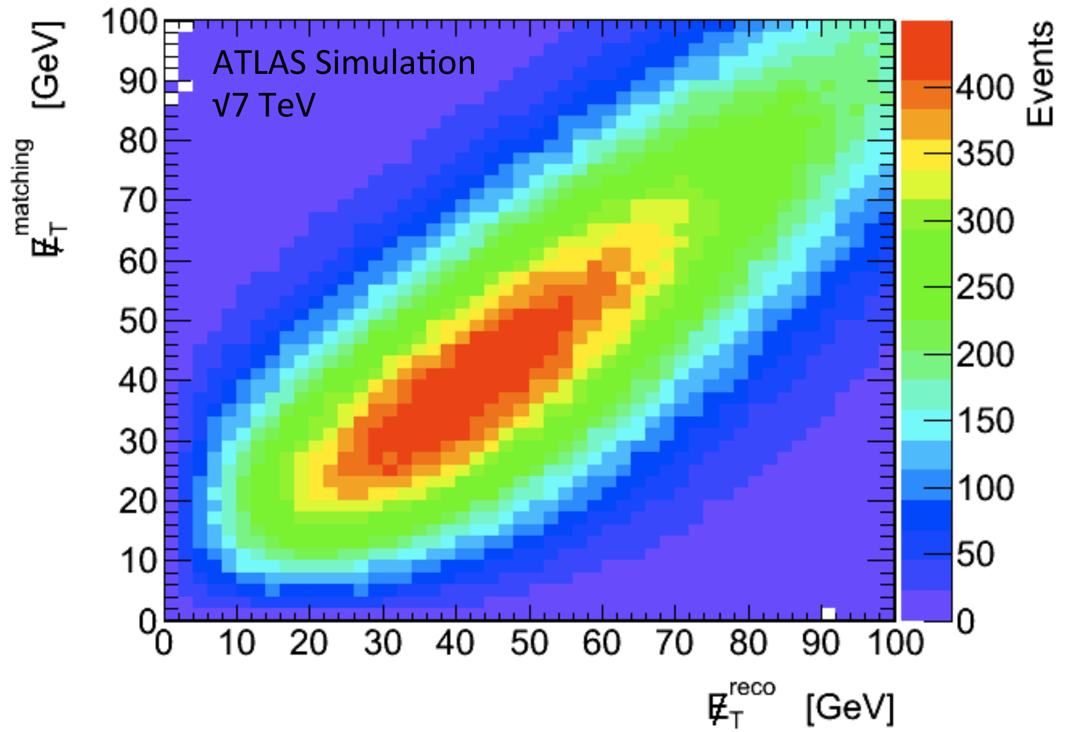
- Discussion with TH, CMS and ATLAS (March 12, 2012)
- Further informal discussions between CMS and ATLAS.
  - https://twiki.cern.ch/twiki/bin/view/LHCPhysics/ParticleLevelTopDefinitions
- Remaining questions and details are the focus of the rest of this talk.

CMS and ATLAS: jets and MET

- Do not attempt to 'unfold' between 0.4 reconstruction-level and 0.5 particle-level anti-k_t jets.
  - Compare results with fully calibrated 0.5 anti-kt jets.
    - Requires ATLAS to calibrate the 0.5 point.
- Do not include neutrinos in particle jets.
  - ATLAS SM analyses have included neutrinos in particle jets.
  - However, no b-jet JES correction at present, just an additional uncertainty.
  - If the neutrinos are included in the jets, then neutrinos from W decay have to be removed or additional jets are found.
- MET formed from neutrinos in event.
  - Loop over all stable neutrinos, rather than just neutrinos from W bosons.
  - Difference between W-boson matched neutrinos and MET from all neutrinos is small.

Missing E_T : W-boson matched

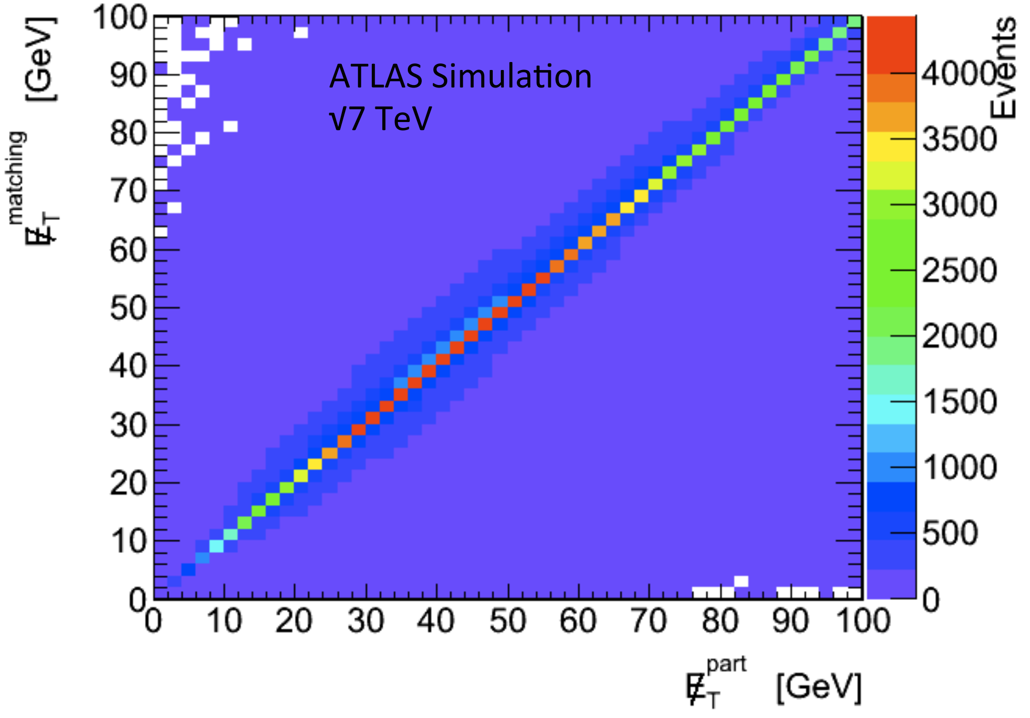
- Study carried out using ALPGEN+HERWIG6 (Np0,..,Np5) ttbar (lnqq,lnln)
- y-axis is the missing E_T from W-boson matched neutrinos.
- x-axis is the reconstructed missing E_T using object weighting of the calorimeter energy clusters.



Correlation, but resolution effects clearly visible.

Missing E_T : W-boson vs total

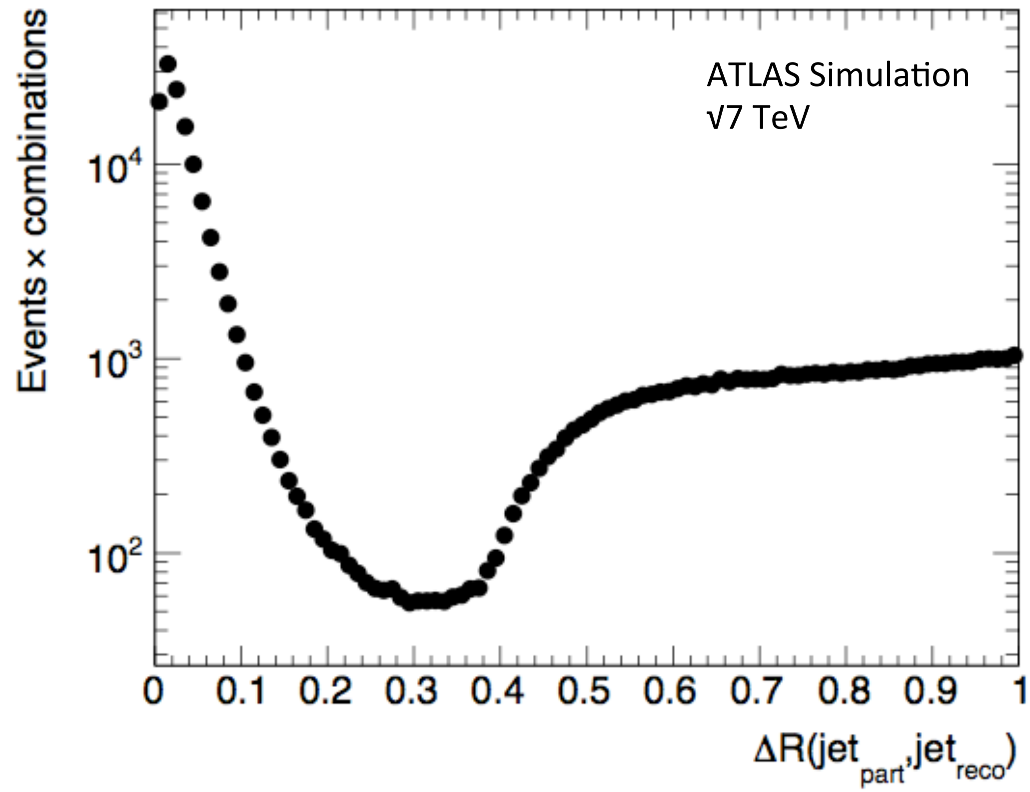
- Study carried out using ALPGEN +HERWIG6 (Np0,..,Np5) ttbar (lnqq,lnln)
- y-axis is the missing E_T from W-boson matched neutrinos.
- x-axis is the missing E_T from all neutrinos in the event.



Neutrinos from leptonic b decays have little effect on the missing E_T

Jets: angular correlations

- Study carried out using ALPGEN +HERWIG6 (Np0,..,Np5) ttbar (lnqq,lnln)
- Single-muon channel, single b-tag event selection.
- 0.4 anti-k_t jets.



Angular resolution tail extends under the jet-jet background.

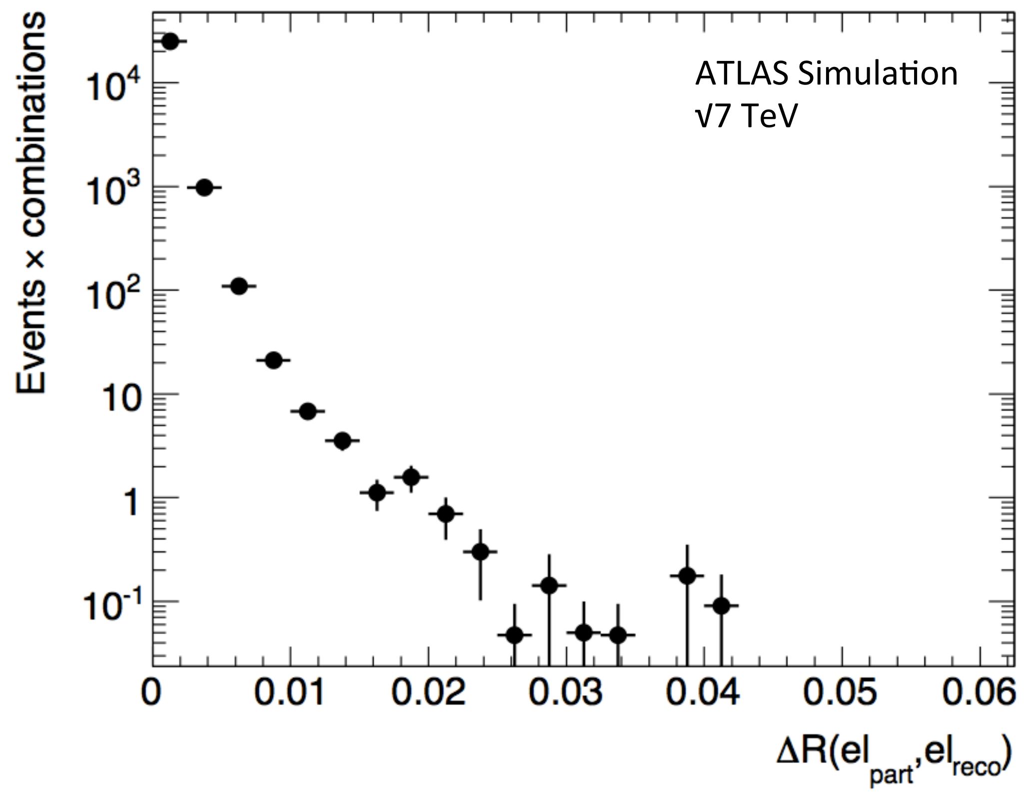
0.5-4% fraction of merged jets for three to eight (p_T > 25GeV, $|\eta|$<2.5) jets in the event, most of the affected events have one pair of merged jets.

CMS and ATLAS: leptons

- Particle-level isolation fulfils two roles:
  1. the selection of leptons from W bosons rather than b-jets.
  2. The removal of events which are not in reconstruction-level selection, where isolation is required too.
- However, lepton scale factors (data/MC) are derived including non-isolated leptons.
  - Need to validate if lepton scale factors are affected by this change to the denominator.
  - Muon scale factors do not appear to be affected.
- Particle-level isolation requirement is not directly related to reconstructed objects.
  - Pileup particles not included in particle-level definitions.
  - Good correlation between track isolation and isolation constructed from tracks $p_T > 1$ GeV, requiring less than 2GeV within 0.3.
    - Tuning to match calorimeter isolation more difficult.
    - Choose 90% efficiency point of 2GeV.

Leptons: angular correlations

- Study carried out using ALPGEN +HERWIG6 (Np0,..,Np5) ttbar (lnqq,lnln)
- Single-electron channel, single b-tag event selection.
- Dressed electron, using particle-level isolation requirement



Clear correlation between particle and reconstruction-level definitions.

Common event selection

Match the event selection used to select the data with reconstructed objects.

Synchronise the electron and muon channels to allow combinations within the selected kinematic range.

Electron channel

- Exactly one selected electron (|η|<2.5 & p_T > 30GeV)
- No selected muons (|η|<2.1 & p_T>30GeV)
- Neutrino sum p_T > 30GeV
- m_T(W) > 30GeV

- At least two b-tagged jets
- At least four particle jets (|η|<2.4 & p_T>30GeV)

Muon channel

- Exactly one selected muon (|η|<2.1 & p_T>30GeV)
- No selected electrons (|η|<2.5 p_T>30GeV)
- Neutrino sum p_T > 30GeV
- m_T(W) > 30GeV

- At least two b-tagged jets
- At least four particle jets (|η|<2.4 & p_T>30GeV)

$$m_T(W) = \sqrt{2 p_T^l p_T^\nu (1 - \cos(\phi^l - \phi^\nu))}$$

Pseudo-top

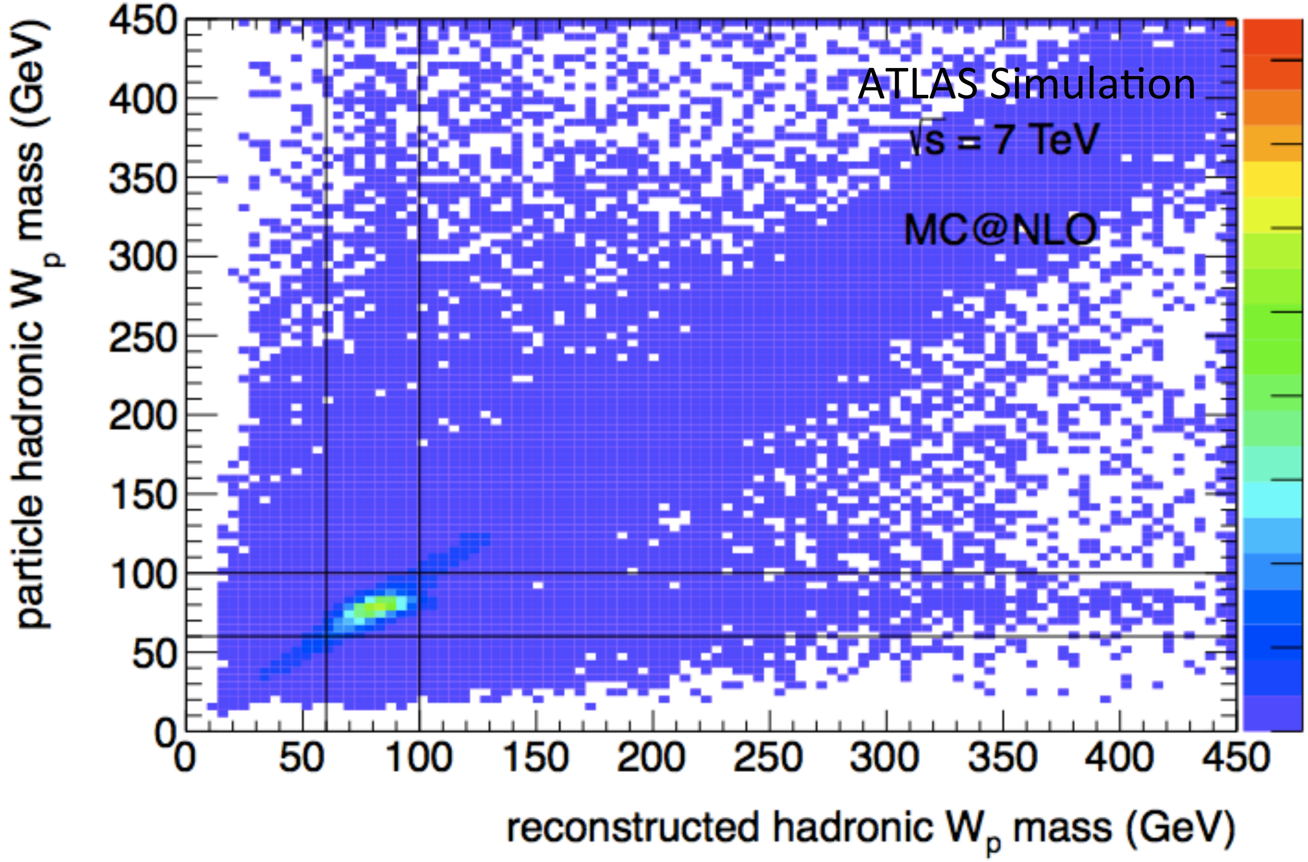
- Rather than define a top quark using a kinematic fitting tool, formulate a top quark using a recipe.
- Unfold from reconstructed pseudo-top observables to particle-level pseudo-top observables.
  - This relies on a reasonable correlation between the two event selections.

Pseudo-top: double b-tag recipe

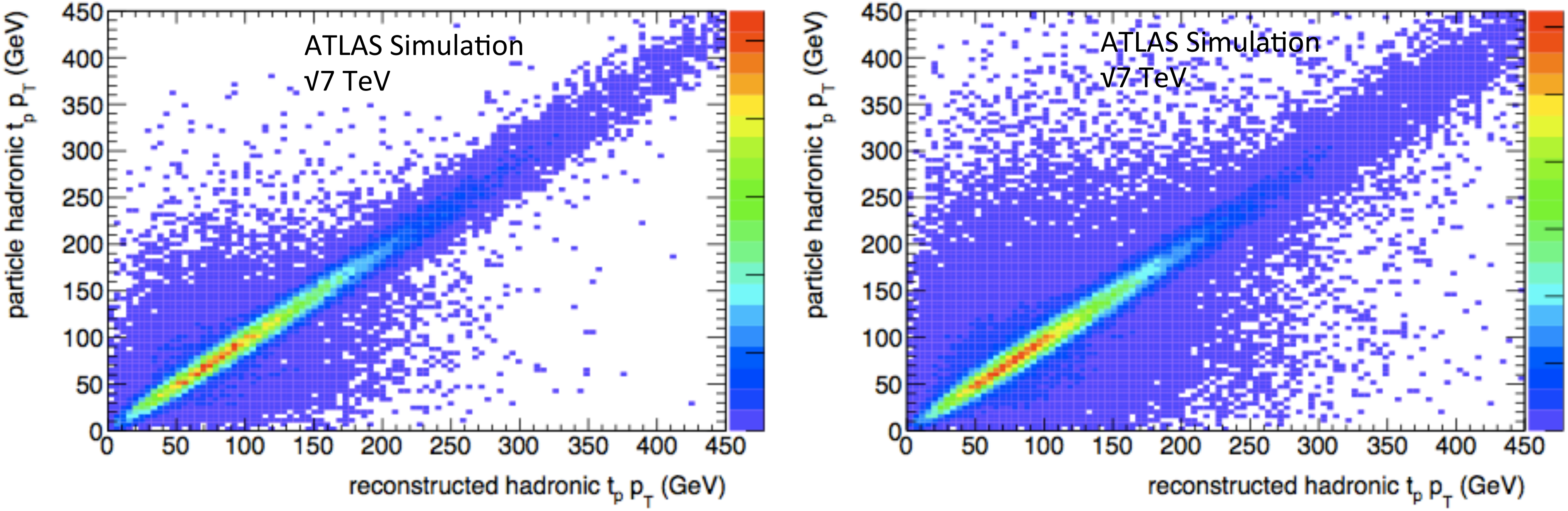
- Require exactly one lepton, at least four jets and at least two of the jets to be b-tagged.
- Assume the leading and sub-leading p_T b-tagged jets are from the top decay (top b jets).
- Form a hadronic pseudo-W from the two highest p_T jets remaining (non-top b jets) .
- Choose the best top b-jet, hadronic pseudo-W combination with respect to the top mass (172.5 GeV)
- Form the leptonic pseudo-W by solving for p_z assuming the W mass.
  - Highest p_z from two-fold ambiguity
- Form leptonic pseudo-top from pseudo-W and remaining top b-jet.

Pseudo-W: double b-tag recipe

- Study carried out using MC@NLO +HERWIG6 ttbar (lnqq,qq)
- Decision on mass cut from unfolding and total systematic uncertainty.

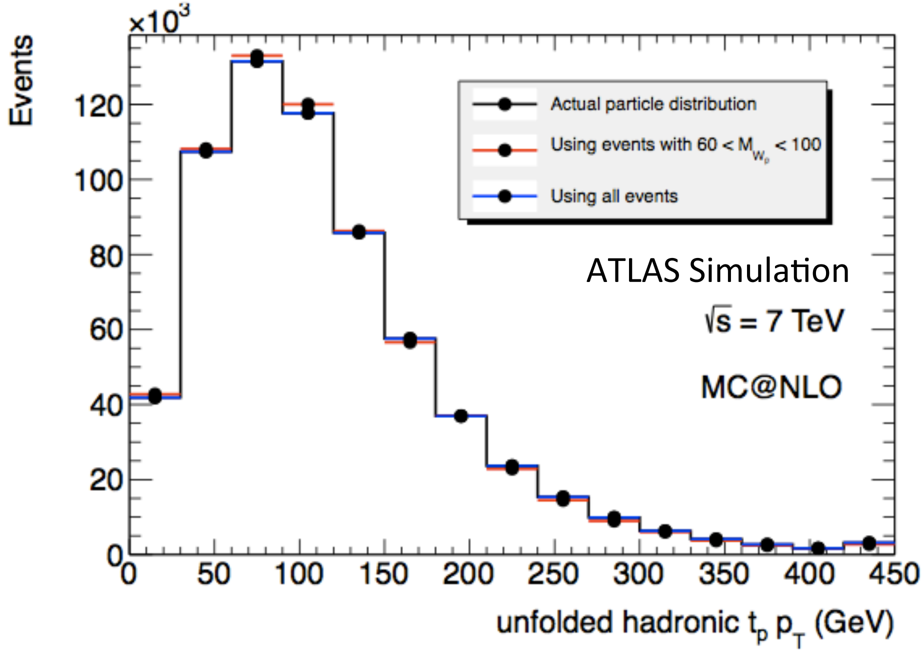


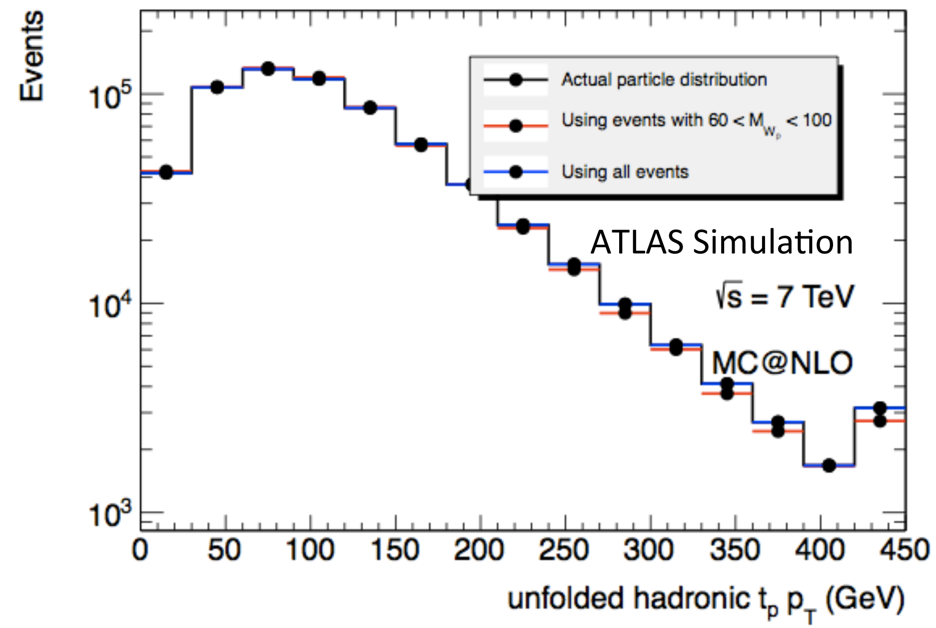
Pseudo-W mass cut: response matrix



The response matrix for the pseudo-top p_T.
Left: with W mass cut, right: without W mass cut

Pseudo-W mass cut: Unfolding





The effect of unfolding with or without the W mass cut appears to be small.
Efficiency and purity correction should be included in this check.

Need to look at the total uncertainty, including MC simulation dependencies propagated through corrections to determine if W-mass cut is needed or not.

Pseudo-top definitions

- Tried several pseudo-top definitions.
  - Presented best definition found so far.
- Double b-tag requirement gives rise to large efficiency corrections.
  - However, single b-tag event selection at particle and reconstruction-level is too different.
  - Lifetime cut on B-hadrons?
- W-mass cut needs to be evaluated in terms of final uncertainties.

Conclusions and outlook

- Converging on common object and event selections for fiducial comparisons.
- Expect rapid progress on remaining points.
- Calibration of 0.5 anti-k_t jets in ATLAS is still on the agenda, but will likely have to be carried out by the analysis team.

Leptons and photon dressing

- A detector clusters ISR/FSR photons emitted along the direction of an electron into the reconstructed electron.
- "Born"-level dressing is difficult to define due to the requirement of separation between ISR and FSR in the generator record.
  - The detector clusters both ttbar+gamma from hard ISR photon emission and FSR from the electron into the same cluster.