Title: Exotics Searches at ATLAS with Jets and MET

Date: Oct 30, 2009 04:50 PM

URL: http://pirsa.org/09100167

Abstract: TBA

Exotic Searches with Jets & E_T^{miss}

PI-ATLAS LHC Conference
October 30th 2009

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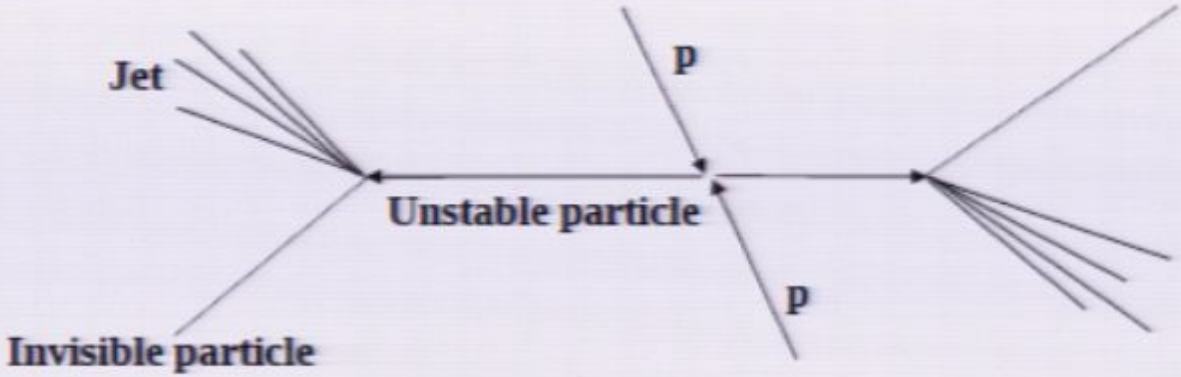
Goals of this analysis

- Formulate an exotics search which can be performed with early data
- What can 'early' data *possibly* imply?
  - Low integrated luminosity
  - Lack of understanding of detector response
  - Malfunctioning hardware (trigger, calorimeter, etc...)
- We tailor the analysis such that it will be as robust as possible in the light of such possible 'problems'
- *Disclaimer: All results shown are for 14 TeV collisions*

Signal Topology



- We are considering events with 2 Jets and Missing Transverse Energy (E_T^{miss})
- Such events can be produced in a myriad of models: Leptoquarks, SUSY, etc...
- Signature is dependent on the masses of the unstable and invisible particles in the model

Event Selection

- Only 2 Jets with pT > 30 GeV
  - 'DiJet event topology'
- Leading Jet pT > 250 GeV
  - Purely motivated by trigger concerns: The Single Jet Trigger (a robust choice) is predicted to be fully efficient at this value
- $E_T^{miss} > 150$ GeV
  - 'E_T^{miss} event topology'
- $\Delta\phi(J_1, J_2) < 2.5$ (Jets cannot be back-to-back)
  - Chosen to reduce QCD backgrounds from di-jet events
- Muon/Electron Veto (Jet $EM_{Fraction}$ + Track Isolation)
  - Reduce electroweak backgrounds

Notice that these cuts are not motivated by any particular model!
Signature-based search

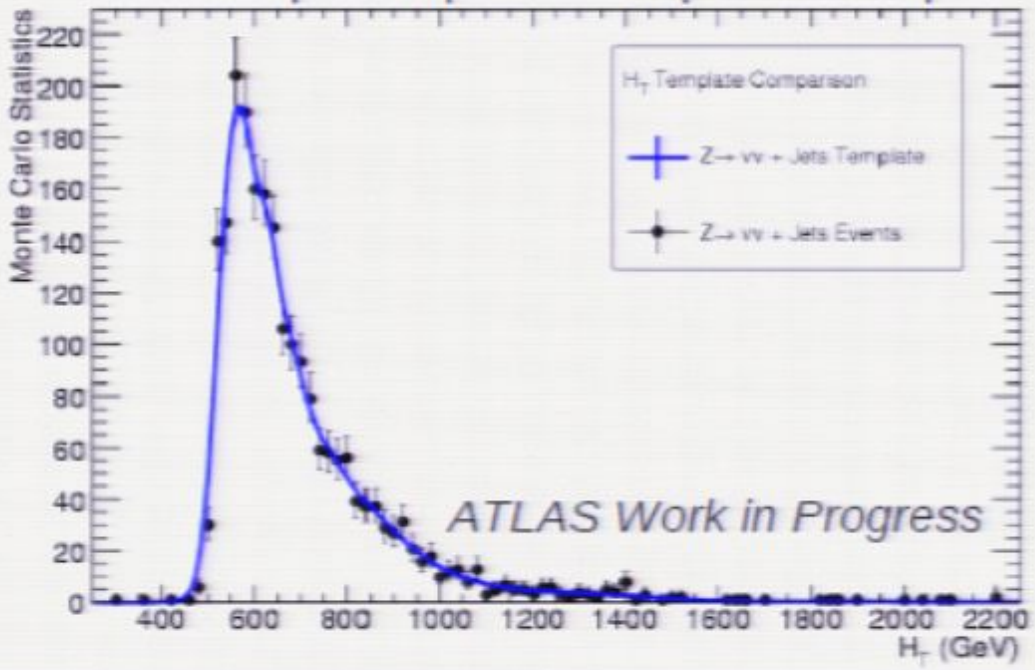
How do we detect signal?

- Traditionally: Counting experiment
  - Using 'rate' information, we can obtain a prediction for the number of Standard Model background events in the Event Sample
  - This can be theoretically-driven (MC Calculations), or data-driven (rates obtained from the data)
- Our suggestion: Template method
  - Focus on using 'shape' information instead. Find the 'shapes' of the different Standard Model backgrounds, and use them to fit to the data
  - We choose to use a data-driven method to obtain the 'shapes', to remove dependence on theoretical calculations

What is a 'shape'?

- We choose a variable which we will use to describe the various backgrounds and signals
- We call a given distribution 'shape' a '*Template*'
- For this analysis, we have chosen:

$$H_T = p_T^{Jet1} + p_T^{Jet2} + E_T^{miss}$$



Note that because the same variable is used for all distributions, systematics will affect all templates in the *same way*!

Procedure

(a) We obtain one template for every background

(b) We obtain the distribution for the data sample

(c) We fit the data with the templates, using the relative normalizations as the only parameters

(d) We apply various statistical tests to determine whether any signal was detected

- We study the feasibility of such a method using various Monte Carlo Samples

Data Sample Contents

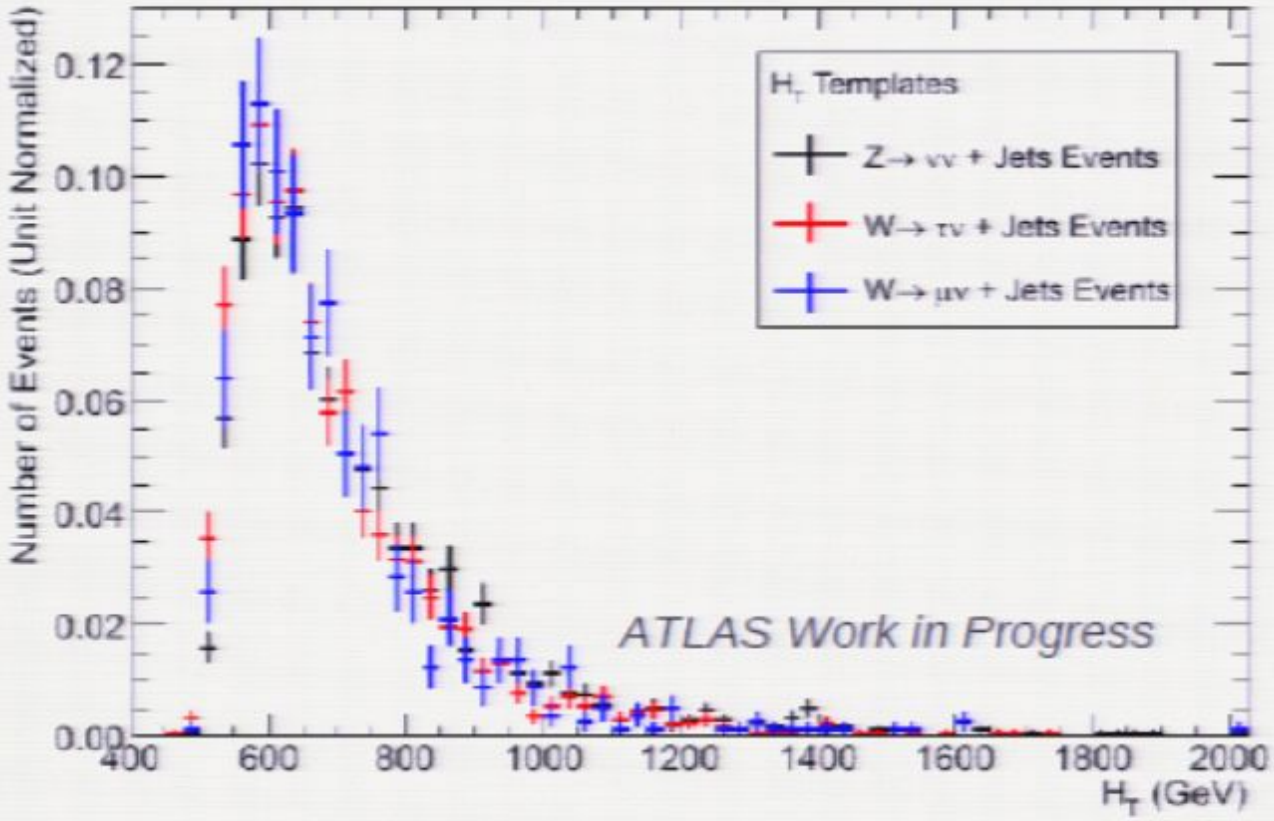
- 'Electroweak' Backgrounds
  - Z→ll + Jets
    - l = ν – Irreducible
    - l = e, μ – Not Vetoe'd ('missed')
  - W→lν + Jets
    - e, μ – Not Vetoe'd ('missed')
    - τ – Hadronic decay
  - Top events (tt̄)
    - All non Fully Hadronic
- QCD Backgrounds
  - MultiJet events with invisible energy
  - MultiJet events with mismeasured Jets
- Signal (we wish!!!)

Tally up!

We potentially need to model ~10 different physical processes!

EW Backgrounds: Simplifications

- It turns out that the H_T distributions for the most significant EW backgrounds are very similar



Take-away:

We can model all significant EW backgrounds with a single template. Needs to be re-verified with data.

Data Sample Contents

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    - ~~l = e, μ - Not Vet~~
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  - ~~Top events (tt)~~
    - ~~All non Fully Hadronic~~
- QCD Backgrounds
  - MultiJet events with invisible energy
  - MultiJet events with mismeasured Jets
- Signal (we wish!!!)

Not statistically significant

Same as Z→νν

Not statistically significant

Tally up!
We're now down to ~4 different physical processes to model!

QCD Backgrounds

- Fake E_T^{miss} can be generated in 2 different ways:
  - Invisible Energy produced inside of jets
    - Decay of Charmed or Bottom Hadrons
      - Found to be insignificant
  - Jet Energy Mismeasurement due to Detector Effects
    - Typically: Sampling (~ 100%/sqrt(E))
      - Insignificant – Would need a ~10 sigma effect
    - However, there are non-Gaussian tails to the resolution, and also non-hermiticity in detector coverage (ie: holes/dead regions)
      - **Can become significant depending on the status of the detector! Will need to be studied in the data!**

Data Sample Contents

- 'Electroweak' Backgrounds
  - Z→ll + Jets
    - l = ν - Irreducible
    - ~~l = e, μ - Not Ve~~
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- QCD Backgrounds
  - ~~MultiJet event~~ ~~visible energy~~
  - MultiJet events with mismeasured Jets
- Signal (we wish!!!)

Not statistically significant

Same as Z→νν

Not statistically significant

Not statistically significant

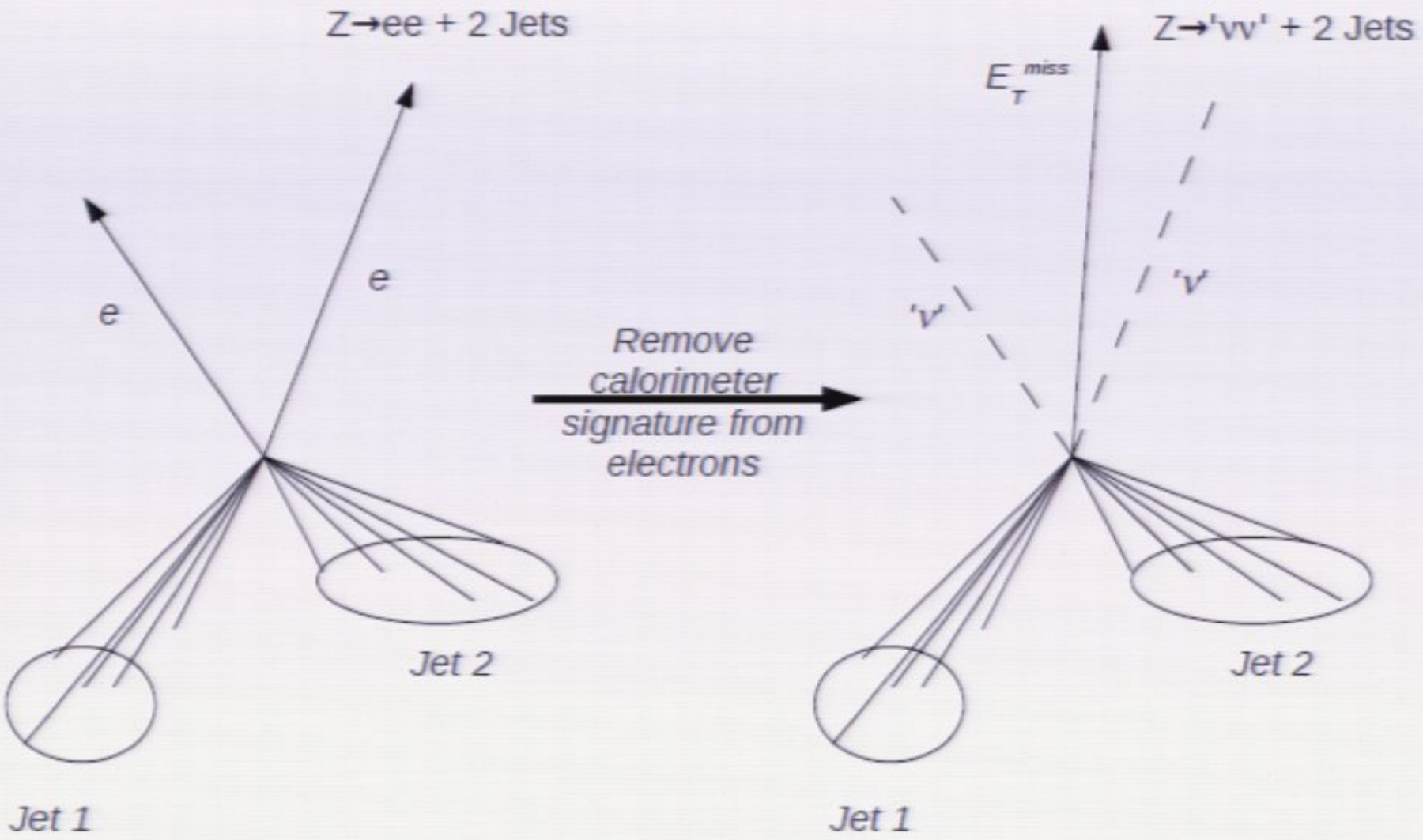
Tally up!

We're now down to ~3 different physical processes to model!

Obtaining the Templates

- We've identified that we need to find templates for **EW backgrounds** and **QCD backgrounds**
  - However, we haven't described how we would do so yet
  - We will focus here on EW (QCD in back-up)
- We construct the Template for the EW backgrounds ($Z \rightarrow \nu\nu$) using samples with well-reconstructed leptons ($W \rightarrow (e,\mu)\nu$) in data
  - We can't use Z samples ($Z \rightarrow \mu\mu$, ee) – Too low statistics
- We remove the reconstructed lepton from the event topology to simulate neutrinos
- Are kinematics expected to be different?
  - m_w and m_z are different
  - Reconstructed leptons have acceptance cuts, neutrinos don't!
    - $p_T > 25$ GeV, $|\eta| < 2.0$

In Pictures – A simple example



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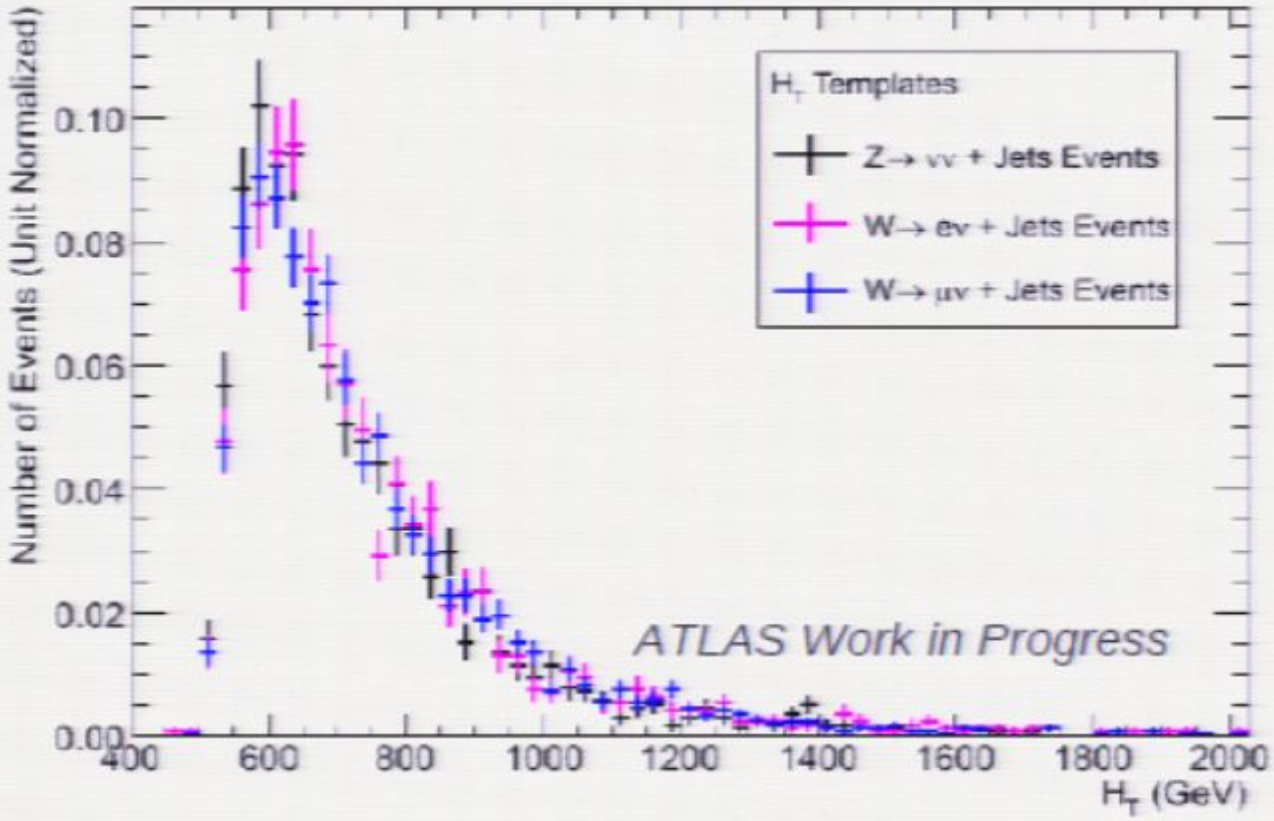
How well does it work?

- The H_T templates are very similar!

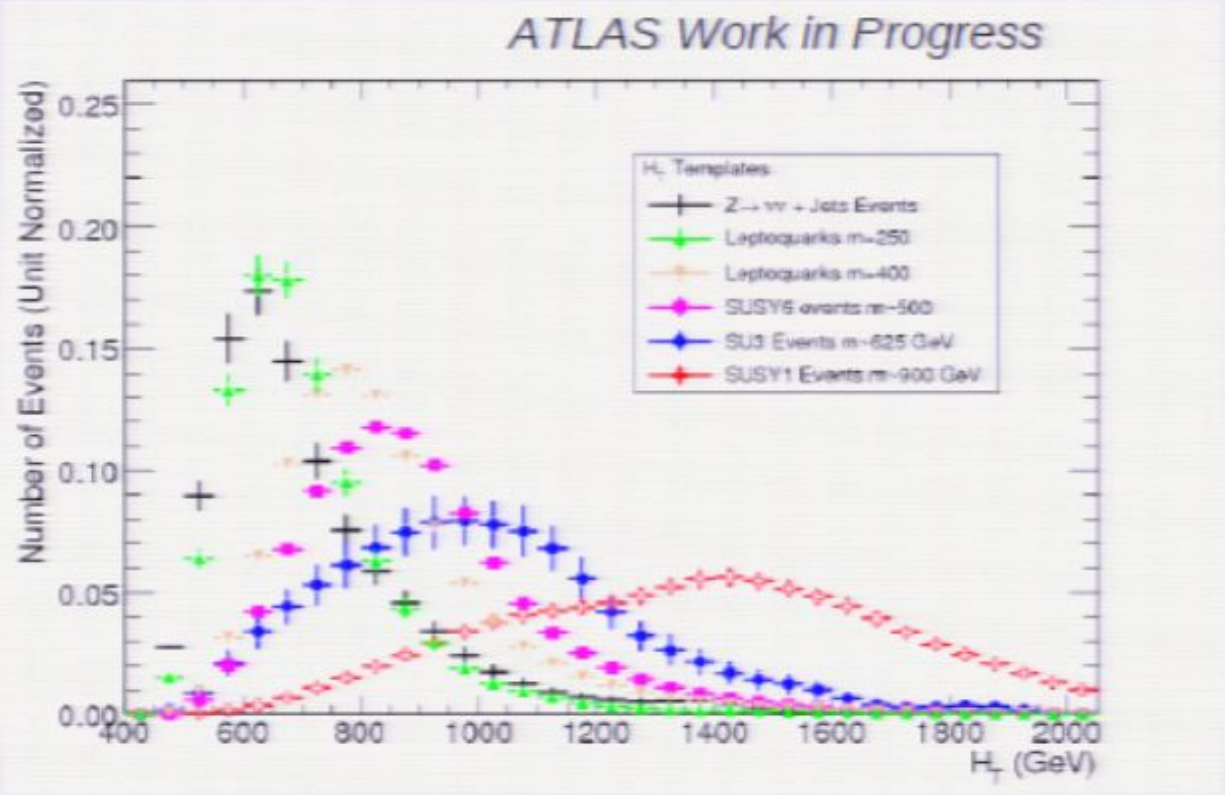


Take-away:

We can model the EW backgrounds using a data-driven method based on well-reconstructed lepton samples

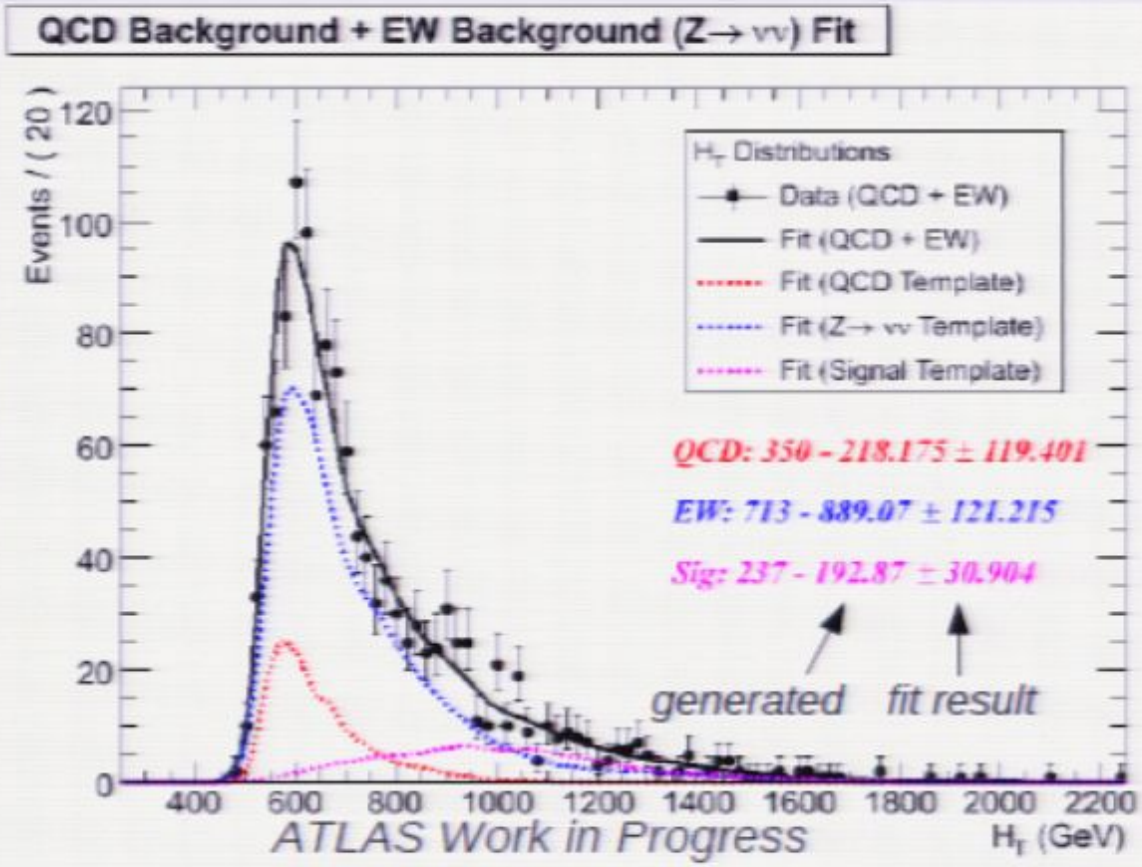
Detecting Signal

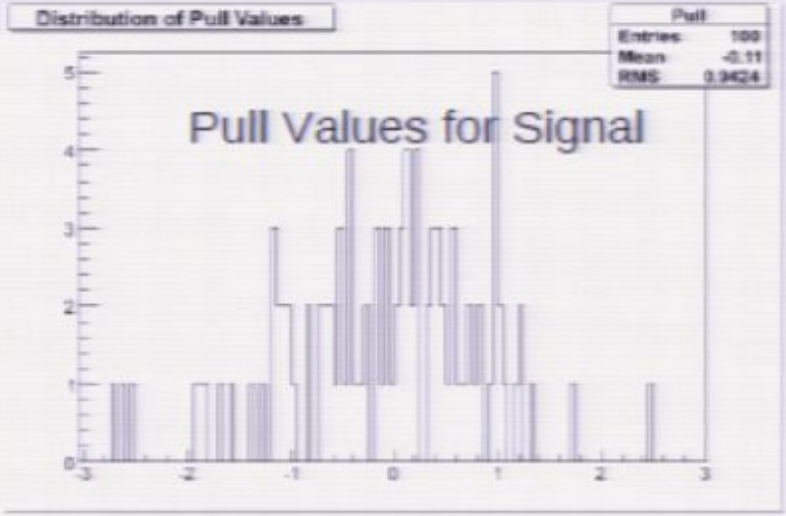
- We show here the H_T distributions for Signal Templates with different mass parameters
- The parameters which define the kinematics are $m_{inv.}$ and $m_{uns.}$



Signal Detection

- We perform pseudo-experiments with EW and QCD templates, inserting some Signal to demonstrate that the fitting procedure works well





Take-away:
Fitter can pick up Signal

Pros/Cons

- Advantages of the method:
  - Almost entirely Data-Driven – No direct need for Monte Carlo, but it can be used to set systematics
  - This method is insensitive to the modelling of efficiencies and acceptances
  - This method should not be affected by incorrect Jet Energy Scale measurements (except for setting limits)
- Disadvantages:
  - Less sensitive than similar studies that make use of rate information
  - Less sensitive than dedicated, optimized searches for specific physics channels

Conclusions

- We've developed a very robust and data-driven background estimation method for 2 Jets + E_T^{miss} final states
- We've shown the potential for background modelling and signal detection using a Monte Carlo study. We will re-verify the assumptions concerning the use of templates with real data
- This method requires a minimum of 300 pb^{-1} of integrated luminosity at 14 TeV to provide enough statistics to create data-driven templates

Detecting Signal

- We show here the H_T distributions for Signal Templates with different mass parameters
- The parameters which define the kinematics are $m_{inv.}$ and $m_{uns.}$