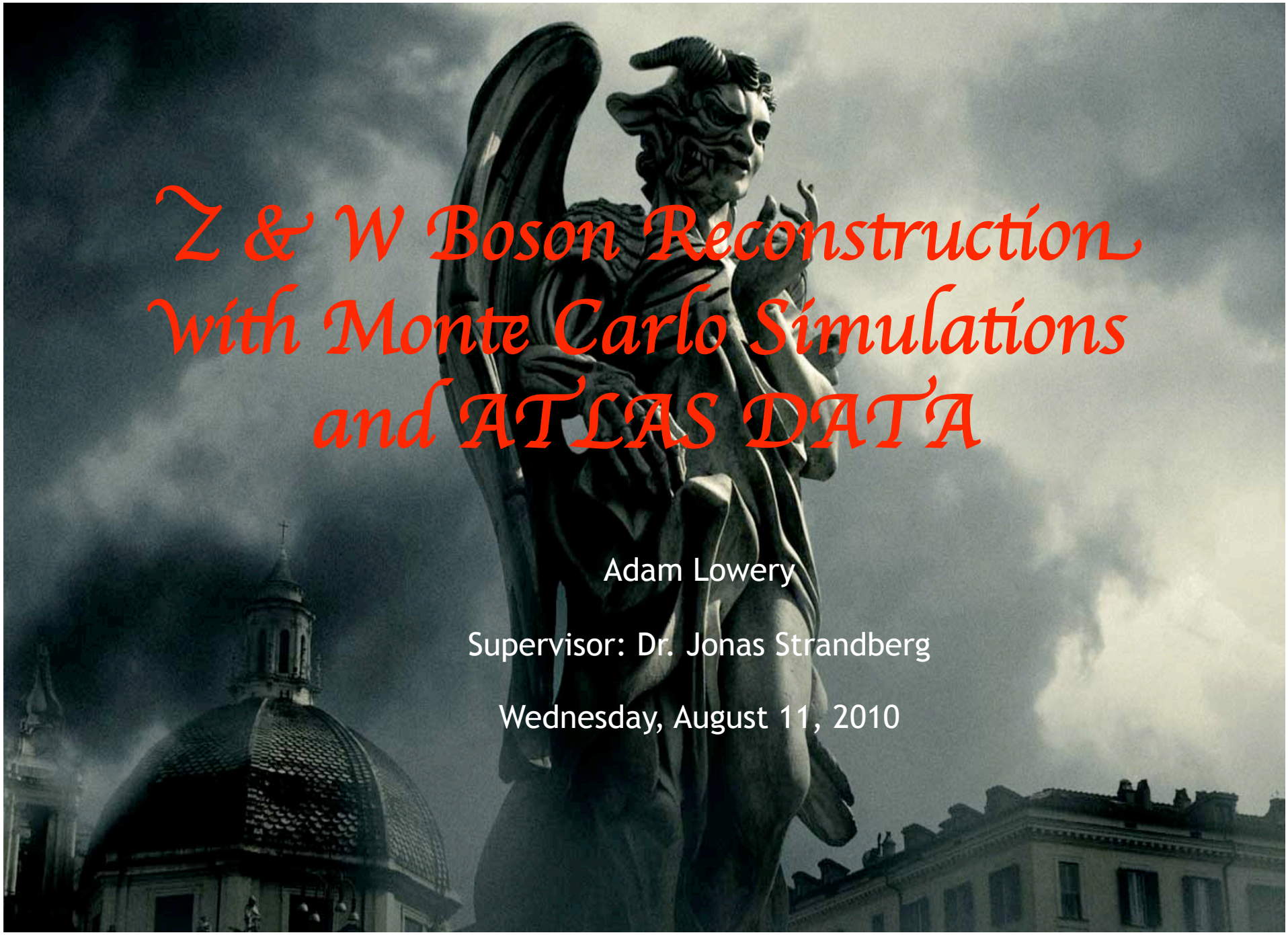

Z & W Boson Reconstruction with Monte Carlo Simulations and ATLAS DATA

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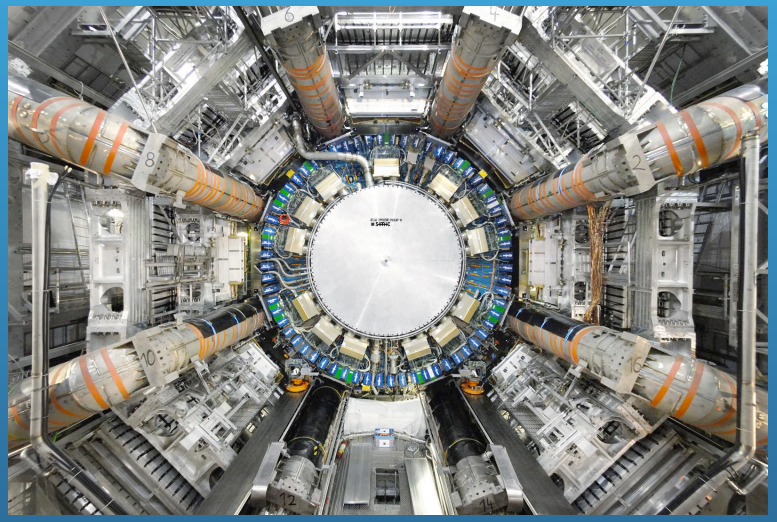
Elementary Particle Detection

The ATLAS Detector



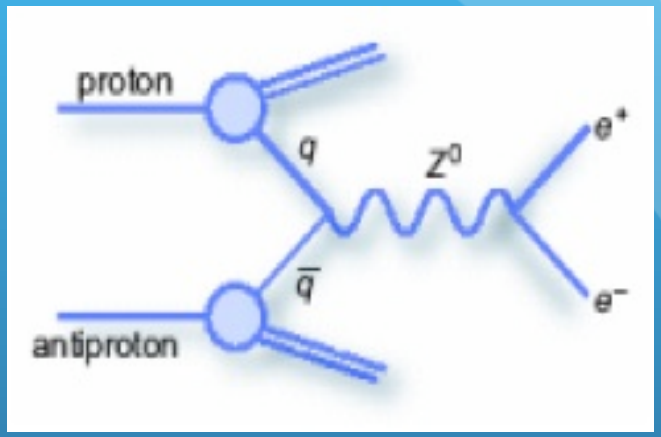
Project ATLAS

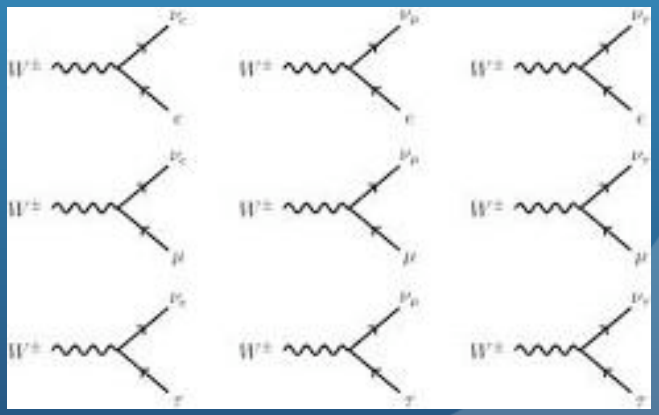
The ATLAS detector is a detector at CERN that monitors of the proton proton collisions within the Large Hadron Collider (LHC). In accordance with the mission statement of CERN, ATLAS hopes to make new discoveries in its overall quest to understand the fundamental particles of our universe. Some of the potential discoveries include the origin of mass (i.e. the Higgs Particle), dark matter, and several possibilities that may still be unknown to us.

Elementary Particle Production/ Deconstruction

Z & W Bosons

Two of the fundamental particles that we have come to expect from the proton proton collisions of the LHC are Z and W bosons. Both of these particles are considered heavy, and also very short lived. From what we known, Z bosons may decay into a pair of leptons while W bosons may decay into a lepton and a neutrino. One of the reasons understanding each of these particles is important is because the Higgs particle could decay into a pair of either one of them.





So…How exactly do we find Z's & W's ?

So, we are given a ridiculous amount of the data from LHC and somehow we have to determine from all the collisions taking place, which one's create Z and W bosons, easy right.

In order to determine which collisions correspond to Z and W bosons we must first have a Monte Carlo. A Monte Carlo simulates what we expect to see from a given series of events and what characteristics we expect to find in our data.

After we have our Monte Carlo, we can apply a series of cuts to the data from the LHC and skim through the events to see which ones meet the criteria that we have set down through our cuts and compare it with our Monte Carlo.

Event Selections

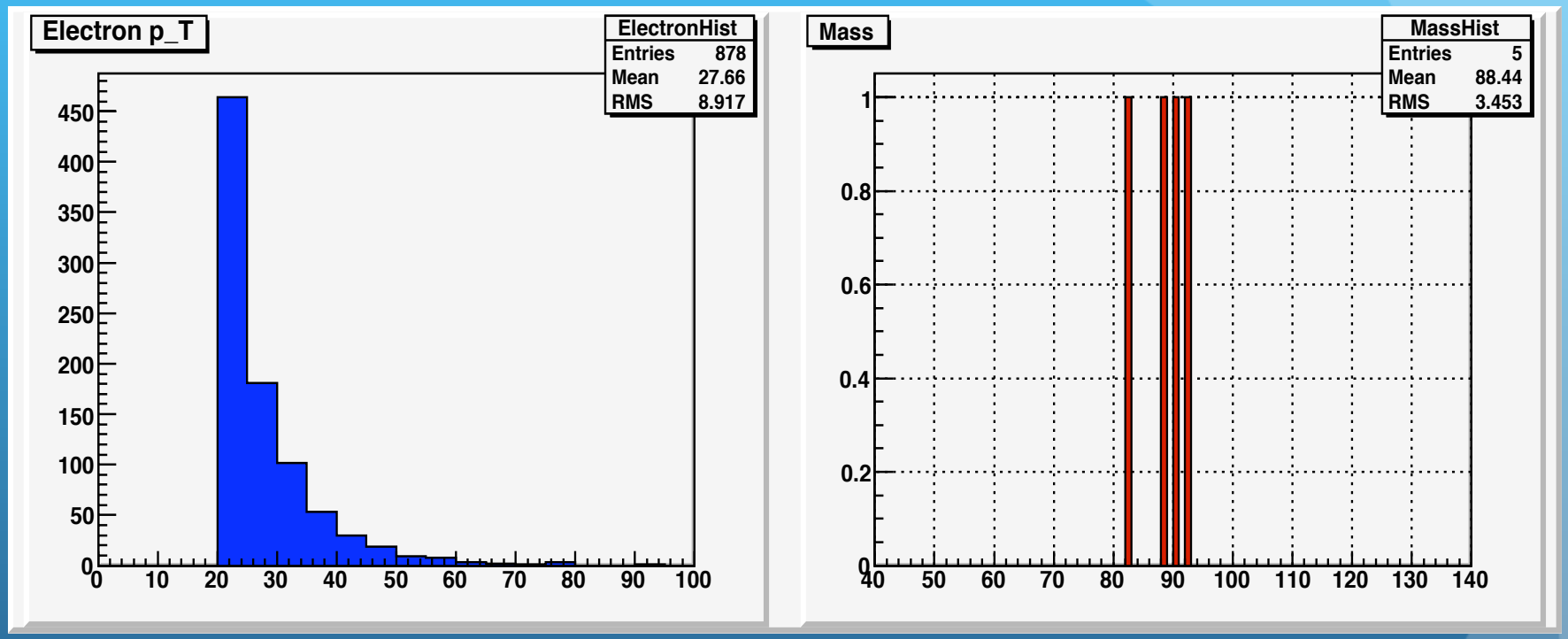
W bosons

- Select 1 muon or electron with Pt > 20 GeV
- Select Missing transverse energy > 25 GeV
- Transverse Mass
  - W bosons ≥ 40 GeV

Z bosons

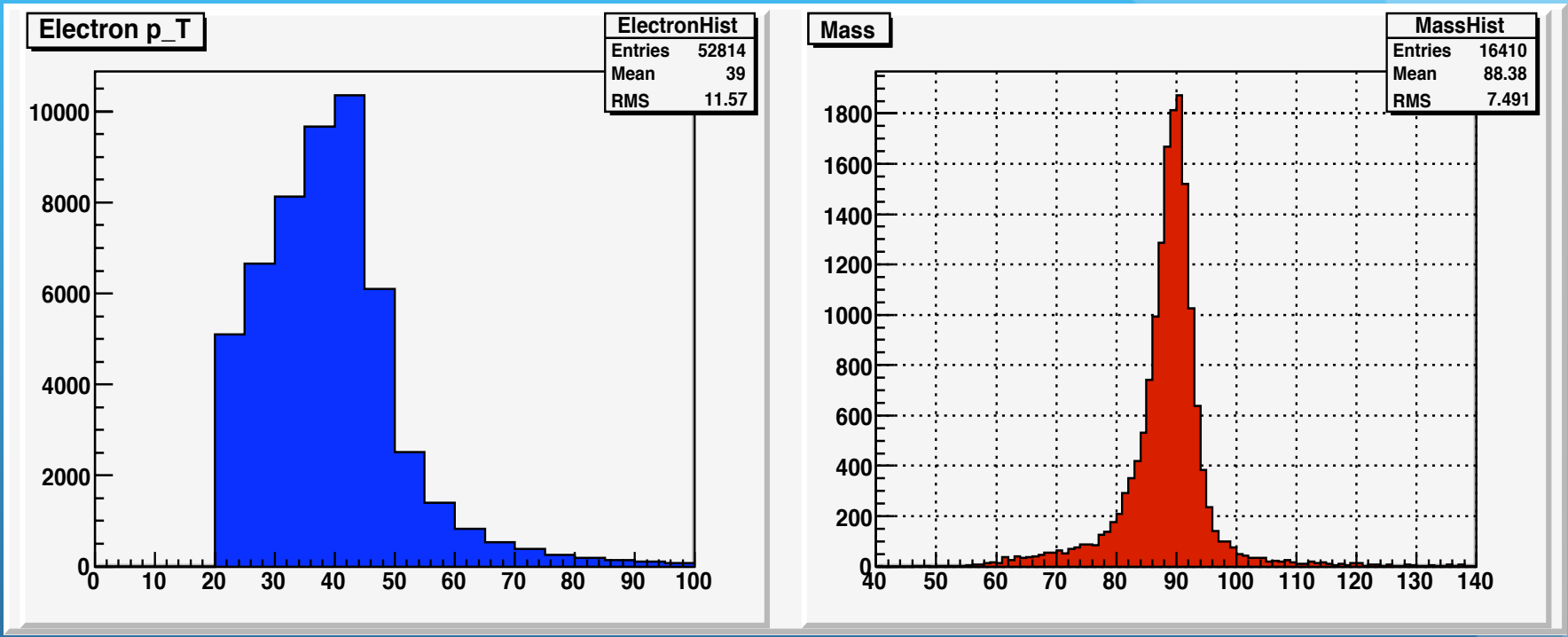
- Select 2 muons or electrons with Pt > 20 GeV
  - Require them to have opposite charge
- Invariant Mass
  - Z bosons mass -> 81 GeV to 101 GeV

My first plots (16nb^{-1})



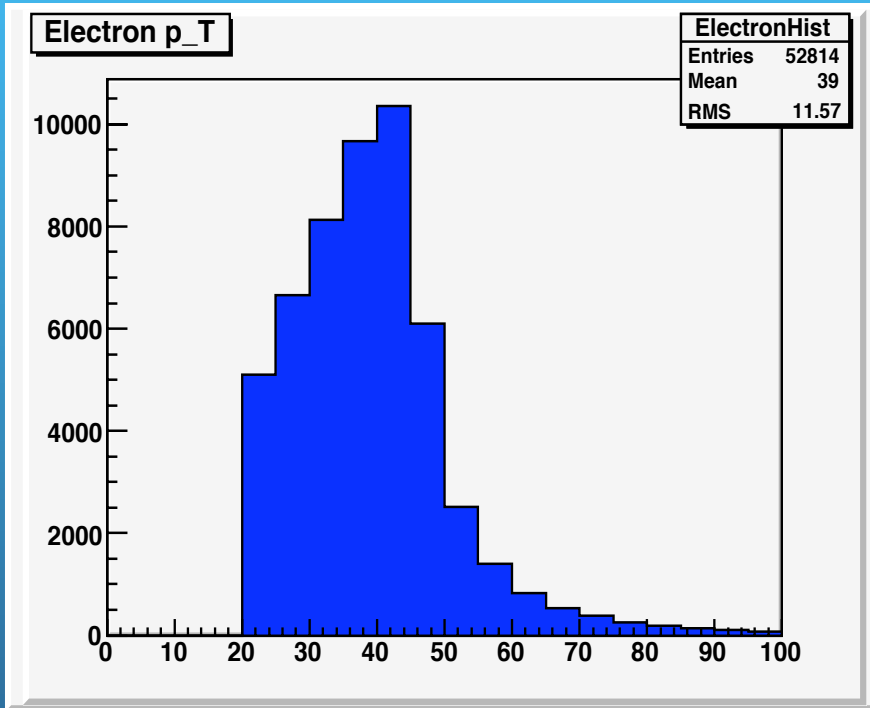
Using data already collected from the LHC we were able to plot the transverse momentum (left) for all of the electrons.
The mass plot (right) shows the mass of Z˚ bosons that were detected.

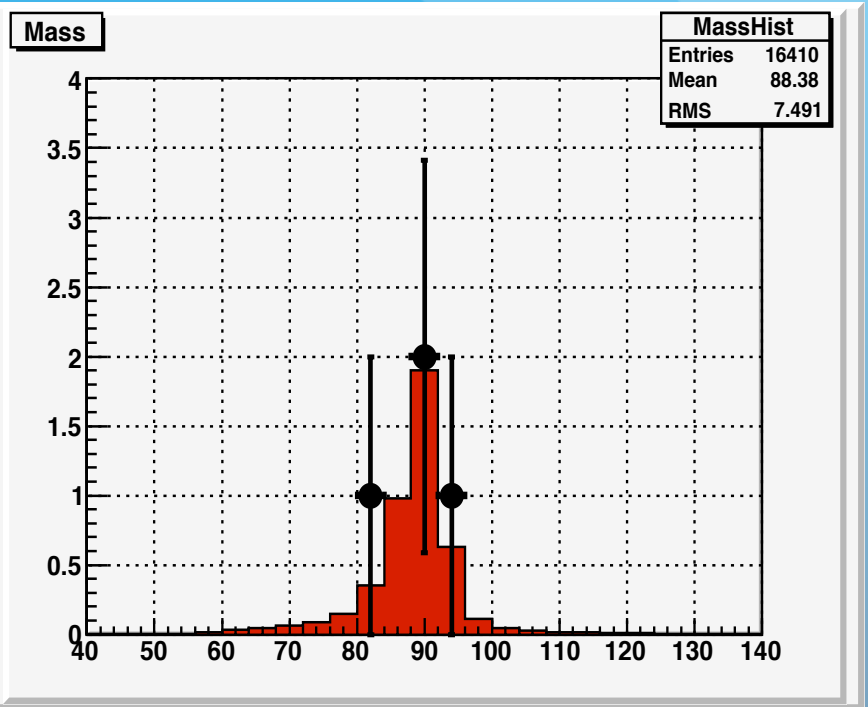
Monte Carlo



The left plot shows all of the transverse momentum for electrons from Z bosons. The right plot shows the invariant mass for all the electron pairs (Z boson mass).

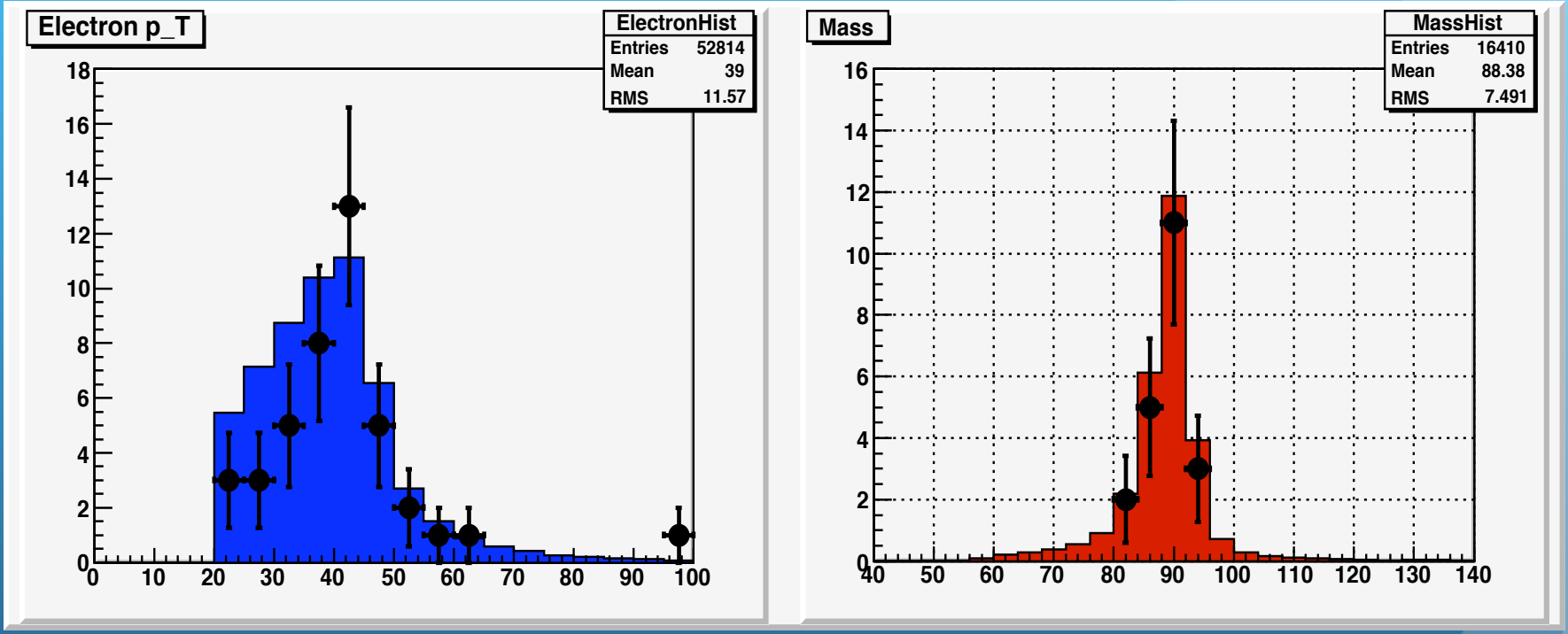
First Data/Monte Carlo Invariant Mass Comparison





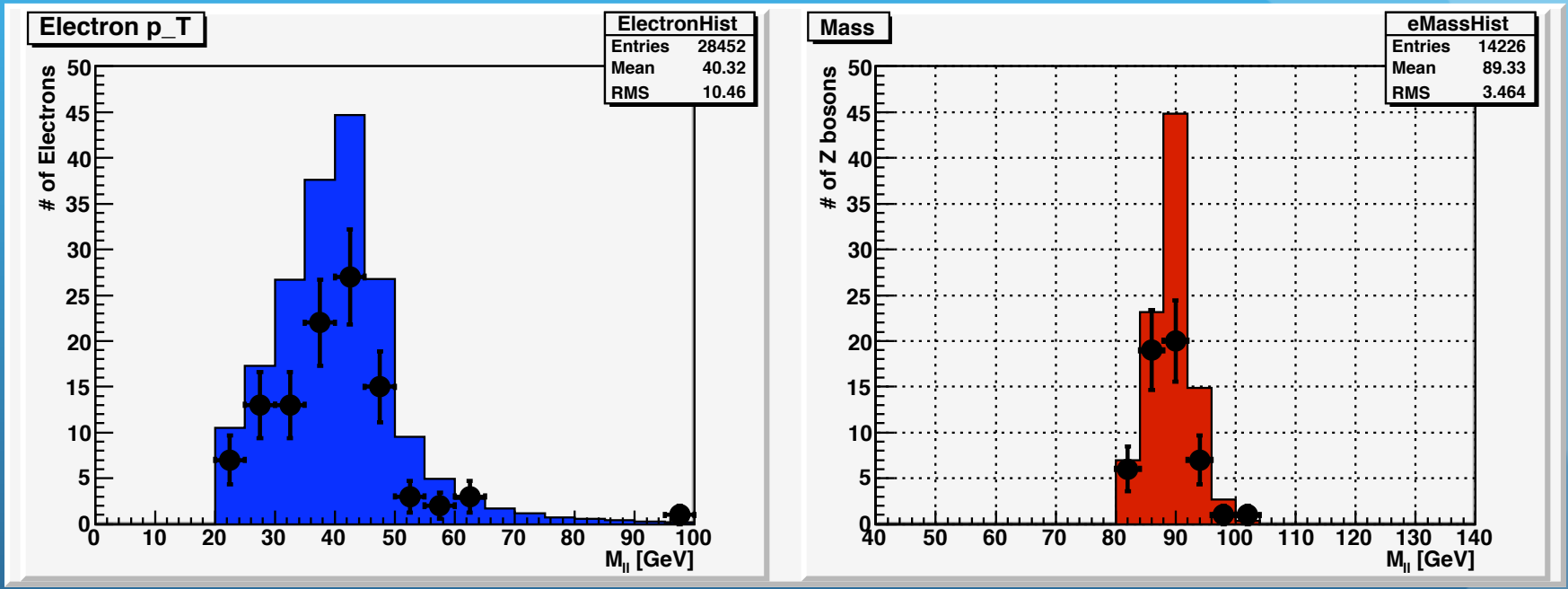
After normalizing the previous histogram to the amount of data (normalizing to an integrated luminosity of 16 nb^{-1}), I was able to plot both the Data and the Monte Carlo on the same plot in order to compare the results.

More Data from the LHC (Data/Monte Carlo Comparison)



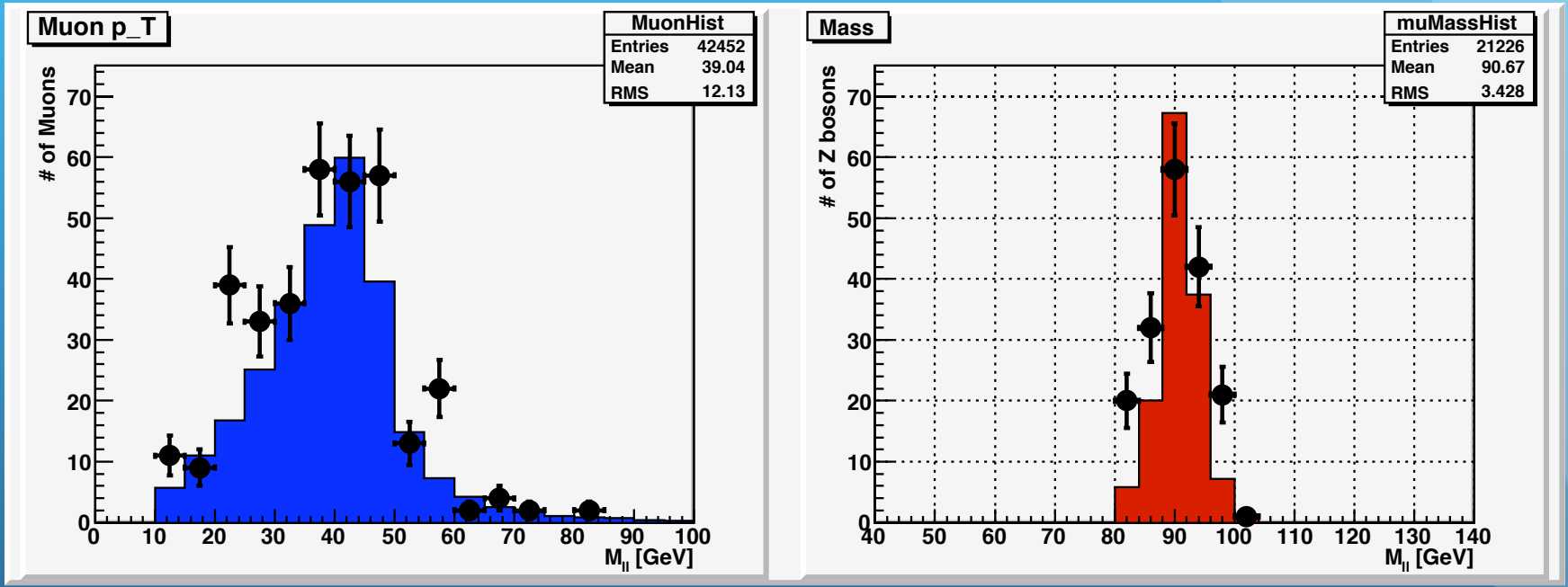
Once more data had become available, we were able to detect 21 Z bosons. From there we created another comparison of the data from the LHC and the Monte Carlo, however in this situation we also compare the transverse momentum along with the invariant mass. Our luminosity value for this comparison increased to 100 nb^{-1}.

Z -> ee reconstruction
(Additional Data received from the LHC)



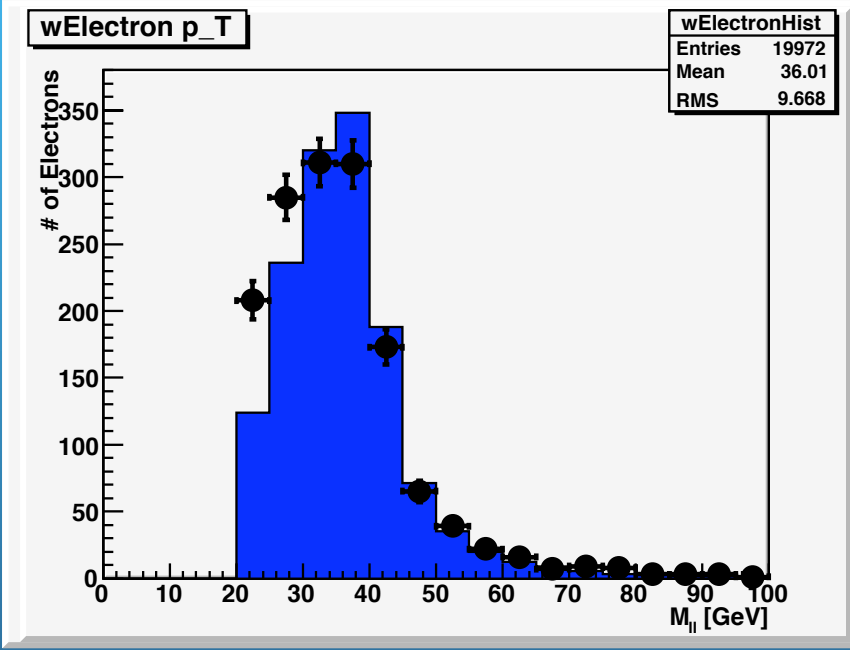
After receiving additional data that had been collected from the LHC, I repeated the comparison method again only this time the luminosity was increased to 330 nb^{-1}.

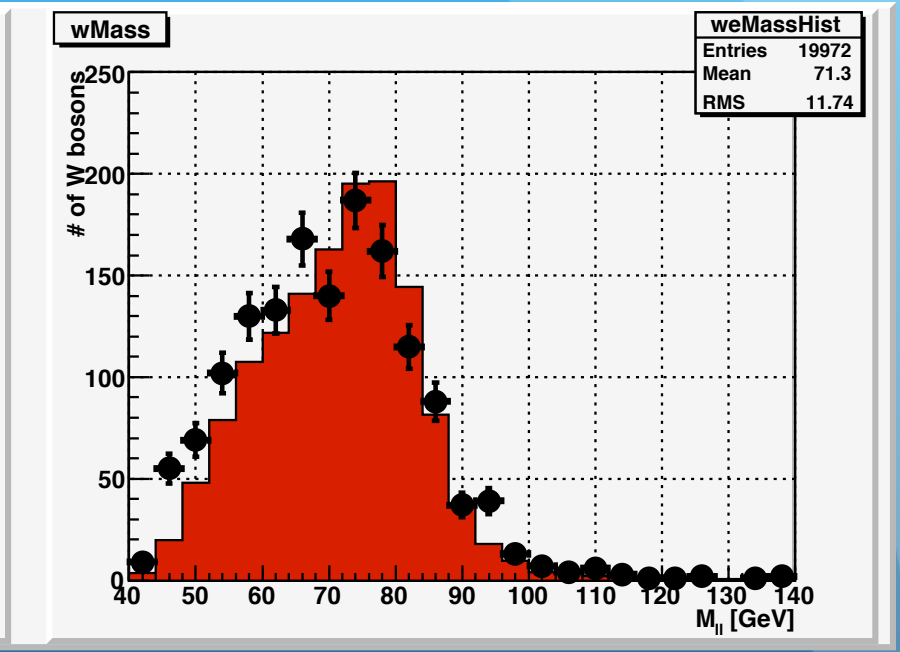
Z -> μμ reconstruction



After plotting the Z -> ee reconstruction, I skimmed through the data again and searched for Z –bosons that had decayed into muon (μ) pairs.

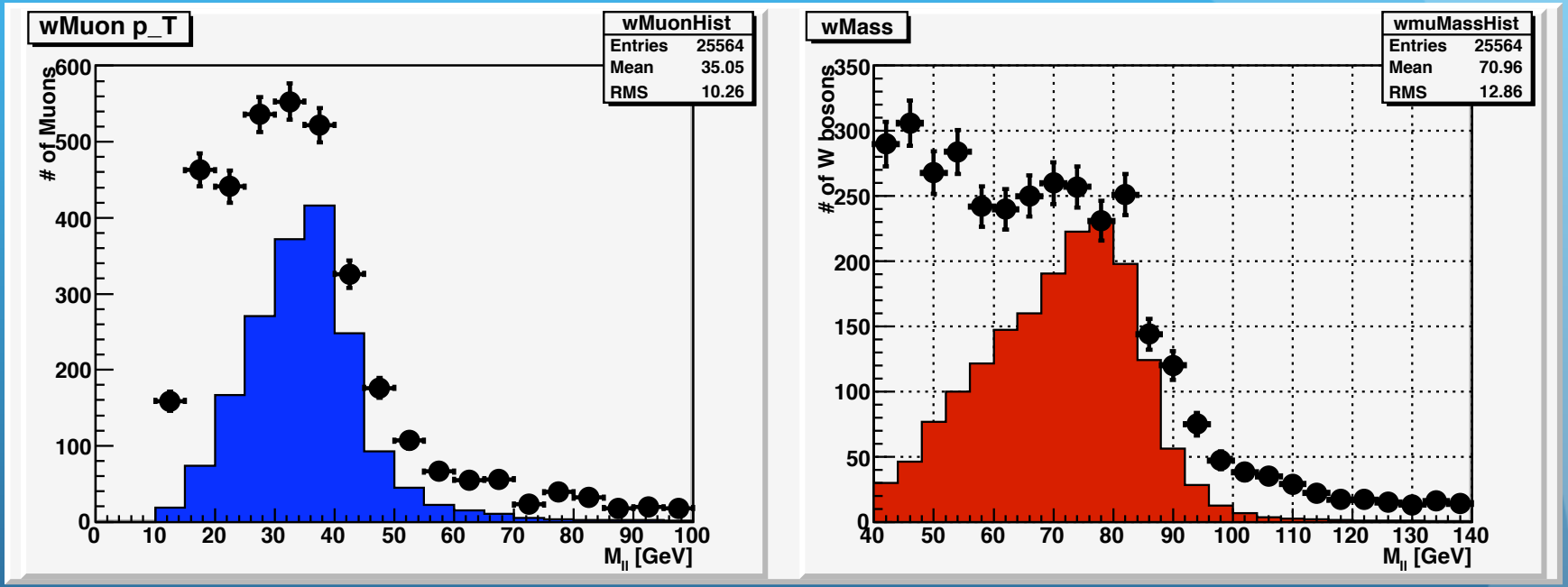
W -> e Reconstruction





After selecting the Z bosons events, I followed up my search by looking for W bosons. I began by looking for W bosons that had decayed into an electron and neutrino.

W -> μ Reconstruction



My final selection process for W bosons was to search for events that decayed into a muon and a neutrino. Discrepancies most likely due to background which has not been taken into account.

What can be concluded from this study?

- We now have a pretty sound method of reconstructing Z and W events.
- We should have a good idea of what the outcome of Z and W boson decay will yield for us and frequency of those results.
- Factors that may affect our results are background events and possible complications with our detector.

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Des Questions?