252B Final Project

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QUESTION 1

The top always decays to a W and a b quark. The W has several decay channels available to it. It can decay to a lepton and a neutrino with a branching ratio of 0.324, or it can decay hadronically with a branching ratio of 0.676. Leptons do not give off jets. The hadronic decay mode of the W is a c quark and another anti-quark (most likely anti-strange). Each of these quarks will give off a jet as they hadronize. So a W which has decayed hadronically will produce two jets. Each b quark will produce a single jet. Ignoring jets from background reactions, the top pair events will have 6 jets 0.46 of the time, 4 jets 0.44 of the time, and 2 jets 0.10 of the time. The average number of jets is 5, and the most likely number of jets is 6.

QUESTION 2

The reason that there are so many enteries in the zero bin of the sample is that the electrons and the muons were double counted. The invariant mass calculation was performed with each electron and itself, and each muon and itself. The result of such an invariant mass calculation is zero. Therefore there is an entry in the zero collumn for every single electron and muon. The decay products of a top dilepton event will be: $e^+\nu_e e^-\bar{\nu_e}b\bar{b}$, $e^+\nu_e\mu^-\bar{\nu_\mu}b\bar{b}$, $\mu^+\nu_\mu\mu^-\bar{\nu_\mu}b\bar{b}$ and these combinations with τ as the leptonic decay of the W.

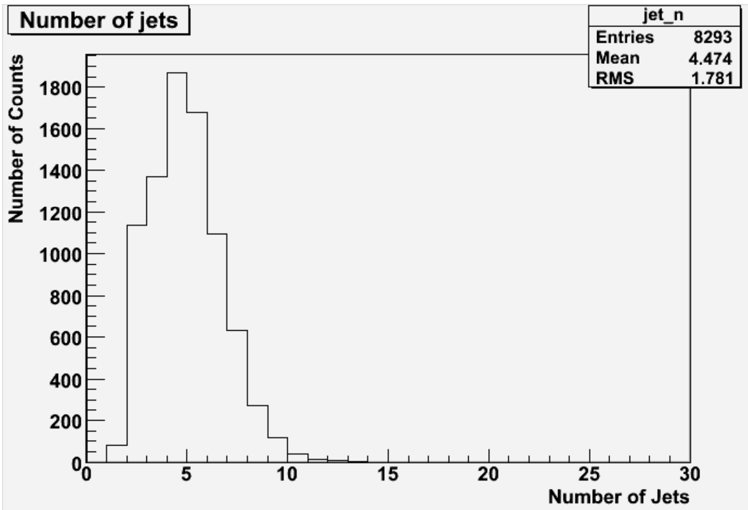

FIGURE 1. Number of jets in dilepton top pair events.

QUESTION 3 AND THE FIRST QUESTION 4

The dijet invariant mass calculation is only able to find the mass of those objects which decay into two jets. In top decays the only product which decays into two jets is the W. The W has a mass of 80.4 GeV/c^2. So we would expect that a dijet invariant mass calculation would return a peak around 80. This does not take into account the jets produced

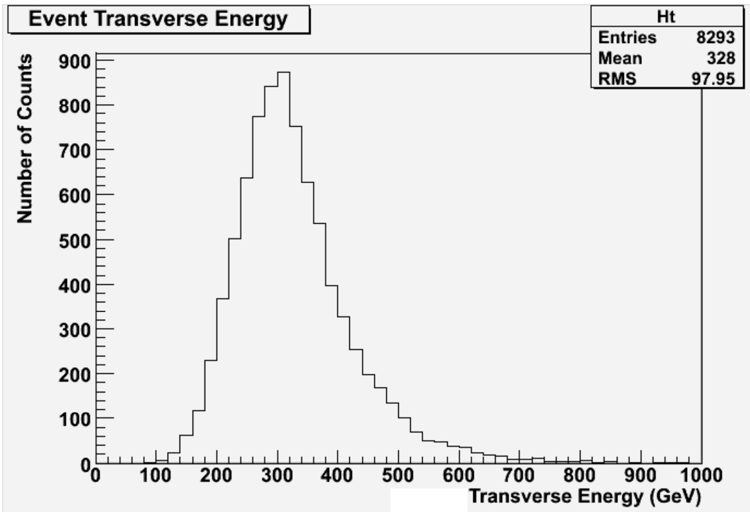

FIGURE 2. Transverse energy for dilepton top pair events.

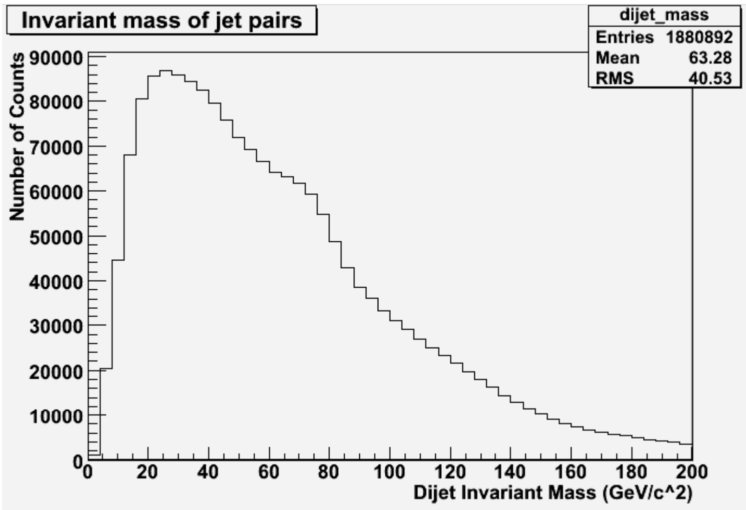

FIGURE 3. Dijet invariant mass for top pair events no data cuts.

by the background or the jets produced by the b quarks. The background jets would have a low Pt since most of the available energy of the collision for particle production must have gone into the creation of the top pair. A cut excluding jets with a Pt less than 20 GeV will lower the background rate so that the W signal is more apparent.

QUESTION 4 THE SEQUEL

The reason there are so many zero enteries in the zero bin of the histograms of the number of electrons or muons is that many events do not produce an electron or a muon. The b quarks do not decay leptonically so they will not produce electrons or muons. As stated in the answer to question 1, 0.46 of the time neither W will decay leptonically. 0.44 of the time one of the W's will decay leptonically, but it can decay to either μ, τ, or e so there will be many single lepton events that don't have electrons and many that don't have muons.

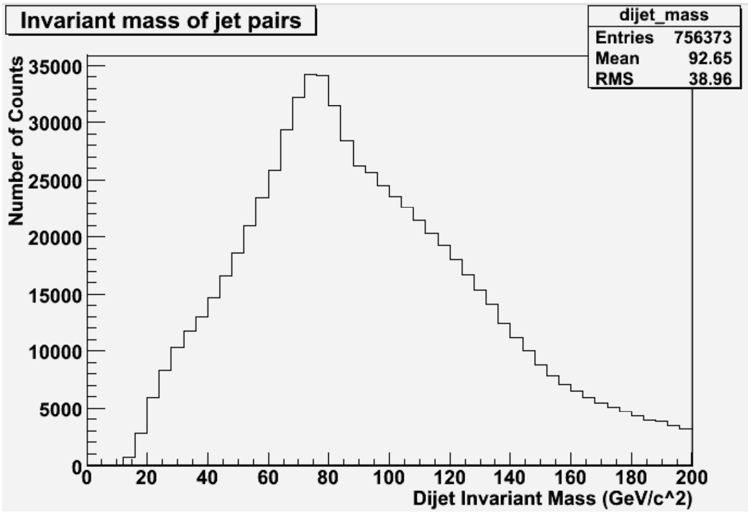

FIGURE 4. Dijet invariant mass for top pair events with a cut excluding jets with a Pt less than 20 GeV

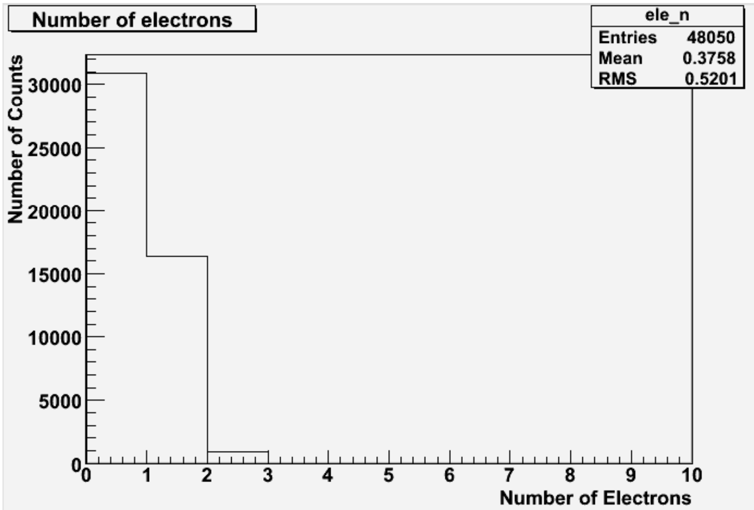

FIGURE 5. Number of electrons in top pair events with at least one muon or electron

QUESTION 6

A top pair event that decays hadronically should have six jets since each W will produce two jets and the b quarks produce another two jets.

QUESTION 7

All the Ht distributions have a similar shape and peak around 325 GeV. This indicates that regardless of the decay method, the top pair event had the same energy. This peak should be at twice the mass of the top quark (170 GeV/c^2)since the transverse energy should be equal to the available energy of the decay, which is twice the mass of the top quark in this case. I am not entirely sure why the peak appears to be slightly under twice the top mass peak, perhaps this is due to an inefficiency in the detection. I think I would have to know more about the generation of the data to come to a valid conclusion.

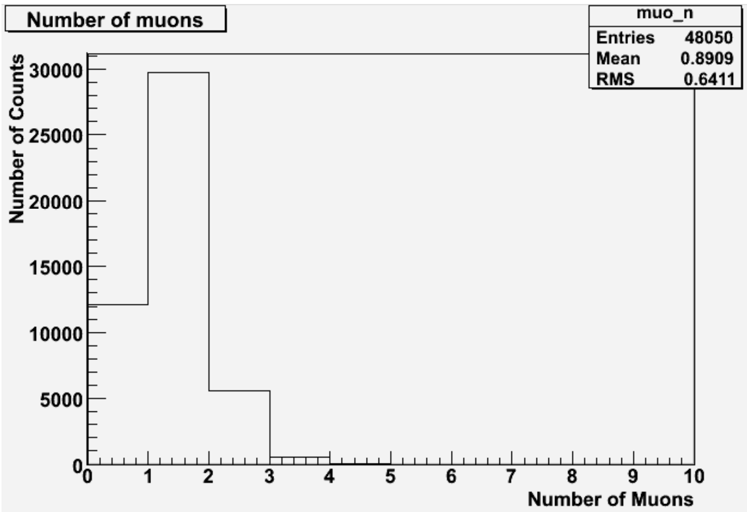

FIGURE 6. Number of muons in top pair events with at least one muon or electron.

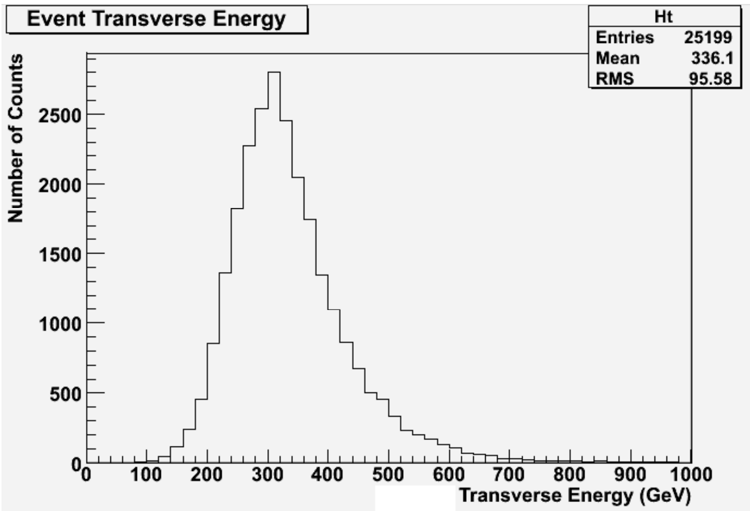

FIGURE 7. Transverse energy for top pair events with at least one 20 GeV electron or muon, at least 20 Gev of missing Transverse Energy and three or more jets.

QUESTION 8

The phi distribution of the missing Et and the muons should be flat because the colliding particles shouldn't have any momentum in the transverse direction. The transverse direction is then a CM frame, and the distributions of a decay in a CM frame are isotrophic. The phi distribution of the missing Et and of the muons for the top pair events was confirmed to be flat.

QUESTION 8 RETURNS

The eta (pseudorapidity) distribution of the the jets appeared to be a guassian centered around zero. If we go to the massless limit this is essentially the rapidity. This is a reasonable approximation considering the energy of the products. The invariant quantity is acutally $d\sigma/p_T dp_T dy$. Assuming the collision happened at z = 0,η = 0 is the point with the highest p_T. So as y increases the p_T has to decrease which will lower the number of particles at those values of y. I'm

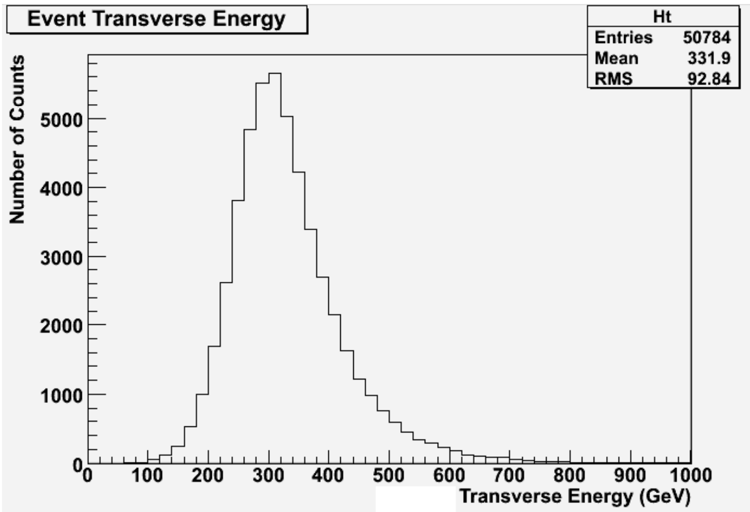

FIGURE 8. Transverse energy for top pair events which decayed hadronically (cut on number of jets > 3).

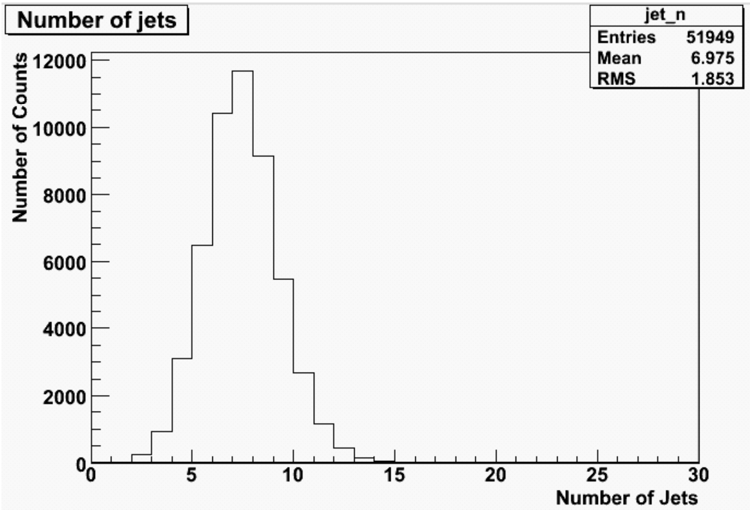

FIGURE 9. Number of jets for top pair events which decayed hadronically (no cut on number of jets).

assuming by the pretty shape of the curve there were no detector issues include in the simulation.

QUESTION 9

There were 8293 dilepton decays, 50784 hadronic decays and 25199 lepton plus jet decays. This totals to 84276, so it appears that my selection criteria is very relaxed. I've included the tau lepton decays in my number hadronic decays so that number will be larger than the quoted branching ratios in question 1. The probability of a dilepton event is 0.10, of a hadronic event is 0.60 and of a lepton plus jet event is 0.30. The probability of a dilepton event should be the square of the probability of a W decaying leptonically. The probability of a hadronic event should be the square of the probability of a W decaying hadronically. If I add the τ decays to the hadronic decays I should have found that the dilepton decays at a probability of 0.05, the hadronic decays at 0.62, and the lepton + jets decays at 0.34. This means I have errors of 116, 3 and 11 percent respectively. It appears that I wasn't as strict with my cuts for the dilepton events as I was with the other events. After thinking about it, I realize that trying to do this without introducing a bias would be quite difficult. Perhaps it would be easier to look at the invariant mass and measure the width of the peak.

QUESTION 10 EXTRA!

A quark or a gluon will produce a jet and the W will produce two jets 0.68 of the time so I would expect that the 3 jet bin would have the most enteries, which is definitely the case. I believe that the extra jets come from background gluons or spectator quarks with enough energy to trip the jet finding algorithm, but I'm not entirely certain how this data set was generated. If a W and a Q were generated and allowed to fly free, there wouldn't be a background. But if this were part of a pp collision there would be background due to gluon radiation and the collision of spectator partons.

QUESTION 10 EXTRA ALSO!!

The W transverse energy plot appears to peak around 100 GeV/c^2. I would have guessed that this would peak around twice the W mass, but perhaps energy is being lost elsewhere (radiation perhaps). To eliminate straight W events from the data, we could cut events with an Ht less than 200 GeV.

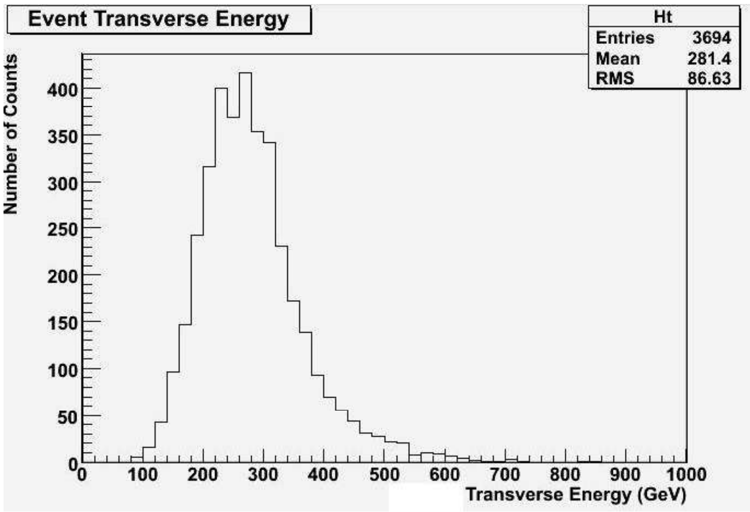

FIGURE 10. Transverse energy for lepton+jets top pair events selected with exactly 3 jets

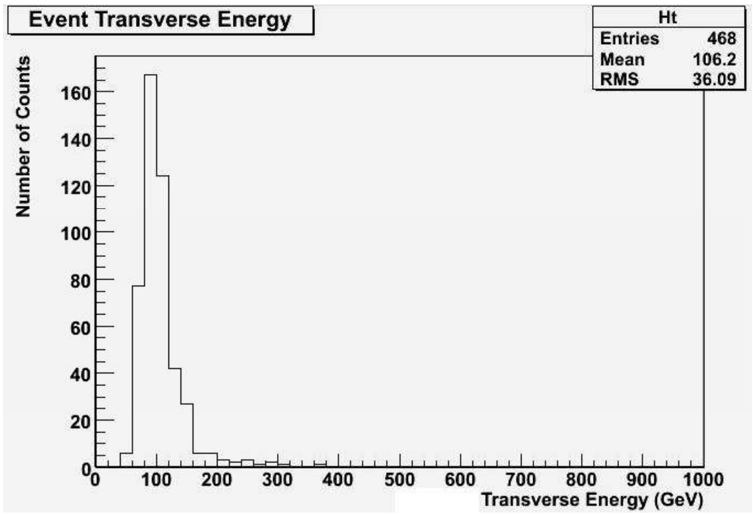

FIGURE 11. Transverse energy for lepton+jets top pair events selected with exactly 3 jets