

# Final Presentation

In association with the UCR CMS Group

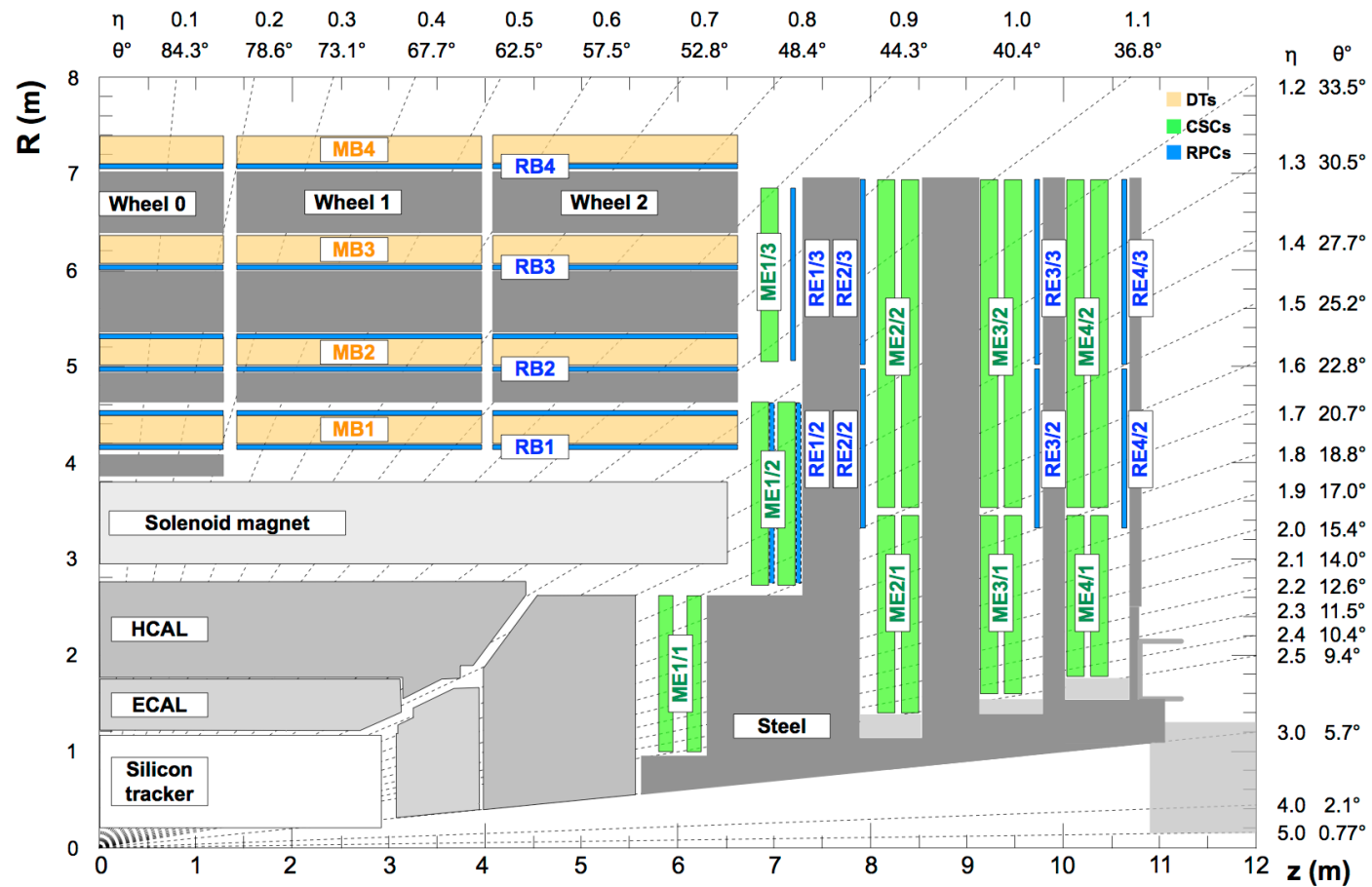
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# At the beginning

- At the start of this program, I was handed two major assignments.
  - 1) Four-Top production analysis
  - 2) CSC upgrades
- What did/didn't I complete?
- What still needs to be done?
- What this opportunity has taught me

# Cathode Strip Chambers (CSCs)

- Let me refresh your memory of the CSCs.
- Cathode strip chambers which are located at the endcap disks where the magnetic field is uneven and the particle rates are high.
- CSCs use perpendicular arrangements of these cathodes and anodes inside an ionizable gas, which detects the passage of muons, and measures their momentum.



# The upgrades

- In LS2, we're replacing the old digital cathode front end boards (DCFEBs) with the new xDCFEBs.
- xDCFEBs are similar to DCFEBs, but they have an increased radiation hardness.
- In addition of installing new ALCT mezzanines to the chambers.
- The old DCFEBs will be sent to the Radioactive Protection in preparation to be installed in the ME2,3,4/1 chambers

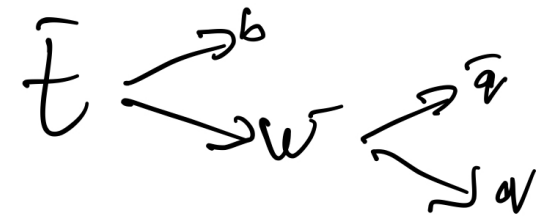
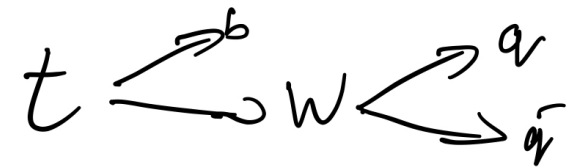
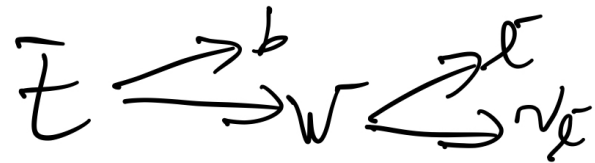
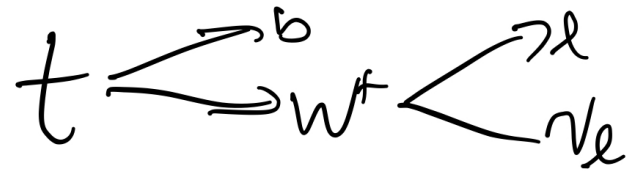
# The progress

- ME1/1 chambers (36 of them) have all been extracted from underground.
- The refurbishment teams have removed the old DCFEBS and installed the xDCFEBs on the extracted ME1/1 chambers.
- Roughly 13 chambers have been finished from refurbishment, 1 chamber has finished all testing is being installed today.
- Testing the xDCFEBs and the new ALCT mezzanines are still ongoing.
- Testing of the 35 remaining chambers from the Minus Endcap is ongoing
- Roughly in June or July ME2,3,4/1 chambers will be extracted

# Four-Top Analysis

- Four-top quark production is a standard model process, and any deviations can be indications of new physics like SUSY, extra dimensions, etc.
- Four top quark production is rare and has yet to be measured.
- What the UCR CMS group is looking for in the Four-Top quark production:
  - 1) Four b quarks – four b jets
  - 2) Two oppositely charged leptons from two quark decaying leptonically.
  - 3) The other two top quarks hadronically decay

# The Decays





# The beginning and the middle

- I was given 2017 run data of events that resulted in final states of oppositely charged leptons.
  - Most events are from background processes, like  $t\bar{t}$  with extra jets,  $t\bar{t}W$ ,  $t\bar{t}Z$ , etc.
- I did evolution plots which to say is adding  $H_T$  cuts.
  - $H_T$  is the sum of all the jets' transverse momentum in one event.
  - The higher the  $H_T$  cut, the fewer background events make it through to final signal and control regions .
- Then I was given more data sets like above except these data sets included a high level trigger (HLT)
  - Filter; reduce rate

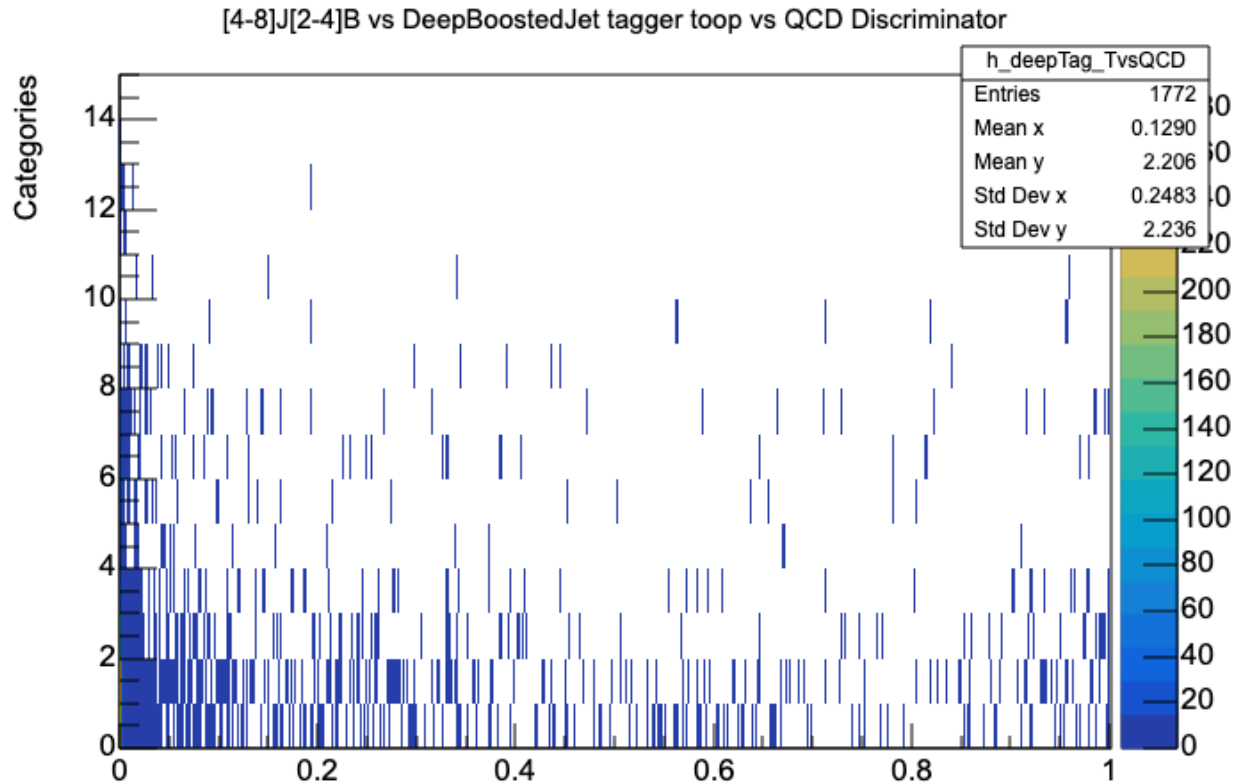
# The end?

- Since the last presentation two weeks ago, I've been working with Monte Carlo simulations of potential backgrounds and the signal.
  - The signal is Four-Top
  - The potential backgrounds: TTTTo2L2Nu, TTTTo2L2Nu\_Njet7, TTHTobbTo2L2Nu, TTTToSemiLeptonic
- Plotted efficiency curves which show the efficiency of the backgrounds and the signal events.

# A Fat Jet

- What is a fat jet?
- Reconstruction of energy deposits and track in the detector with a radius doubled of a normal jet.
  - This uses an algorithm called Anti-Kt
  - Fat jets can be used for clustering multiple jets that came from massive particles like the Z and W bosons, or a top quark, 'together' in one extra-large jet.

# The process



The figure on the left is 2D histogram where the y-axis is the categorization of [4-8]J[2-4]B, J - jets and B - b jets. The x- axis is the TvsQCD Discriminator, where we can see whether the fat jet in our event is likely a boosted top or QCD background.

There are 15 bins corresponding to the [4-8]J[2-4]B categories on the y-axis:

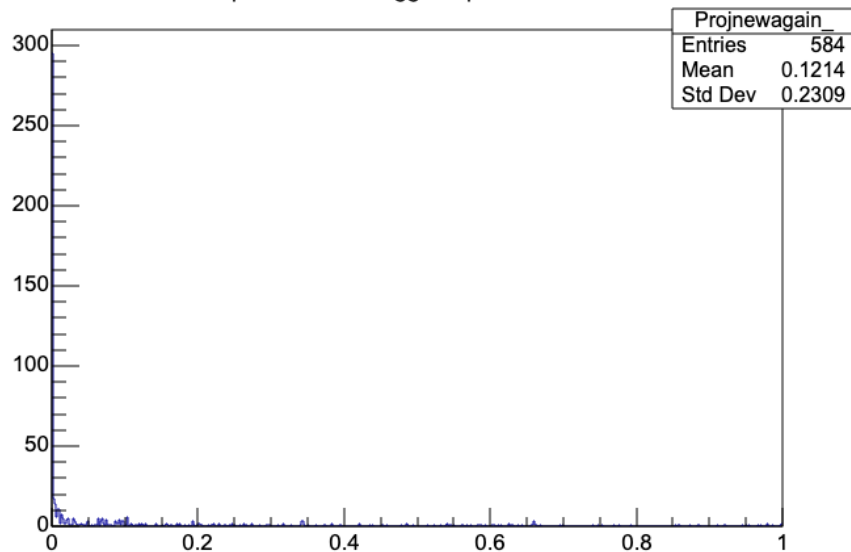
[4-8]J2B are bins 1-5

[4-8]J3B are bins 6-10

[4-8]J4B are bins 11-15

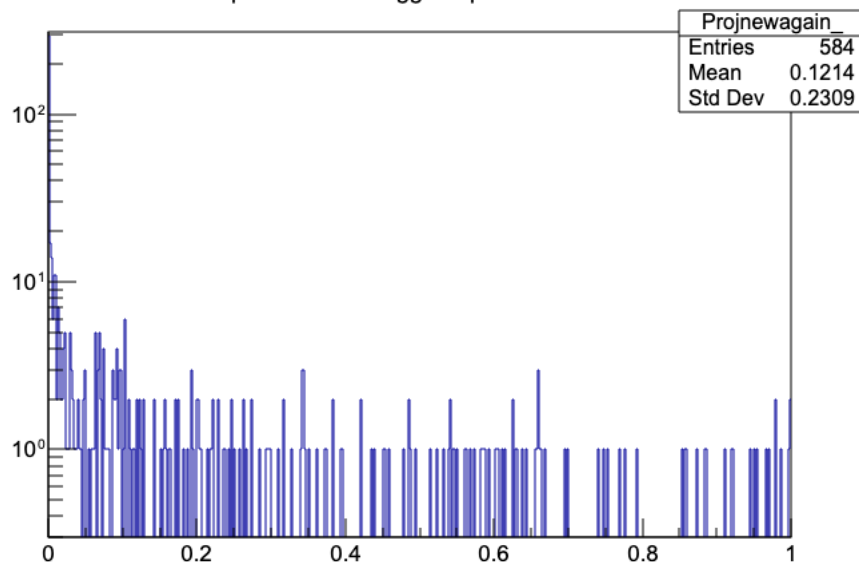
# Continuing on

4J2B- DeepBoostedJet TaggerTop vs QCD Discriminator



Per Category, like on the left, we can project the 2D histogram from the beginning to a 1D histogram that shows us the TvsQCD Discriminator of the fat jet.

4J2B- DeepBoostedJet TaggerTop vs QCD Discriminator



The TvsQCD Discriminator: if we see at one end, e.g. near zero, where the plot is crowded then that means that the fat jet produced in the event is from energy deposits and tracks from QCD processes.

If it were leaning toward the other end, near the highest discriminatory value, then the fat jet was produced by a top quark.

(More discriminators such as WvsQCD, HbbvsQCD)

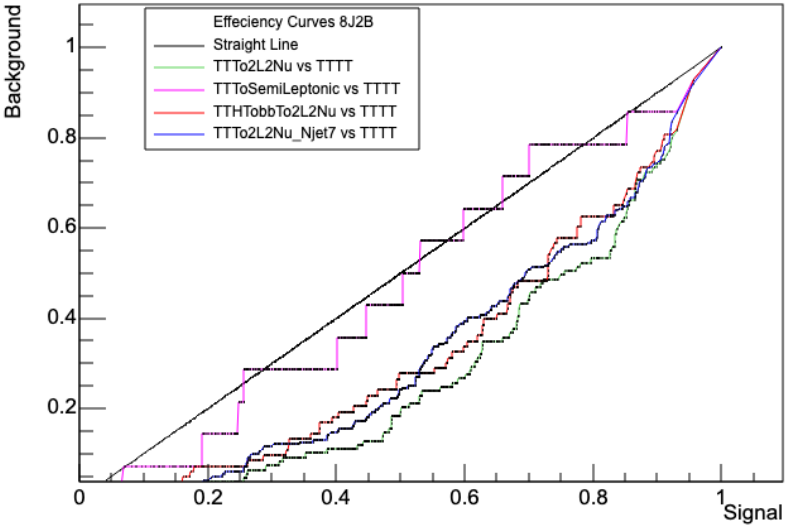
# The Efficiencies

- To achieve efficiencies of the background and signal samples, we get these by integrating bins from a discriminator value up to one in the  $T$  vs QCD histogram and divide by the number of events in the given [4-8]J[2-4]B category.
- Then once we have the efficiency points for the background samples and the signal sample, we set up a plot where the signal efficiency points are on the x-axis and the background efficiencies are on the y-axis.

# Look at these curves: 8J2B

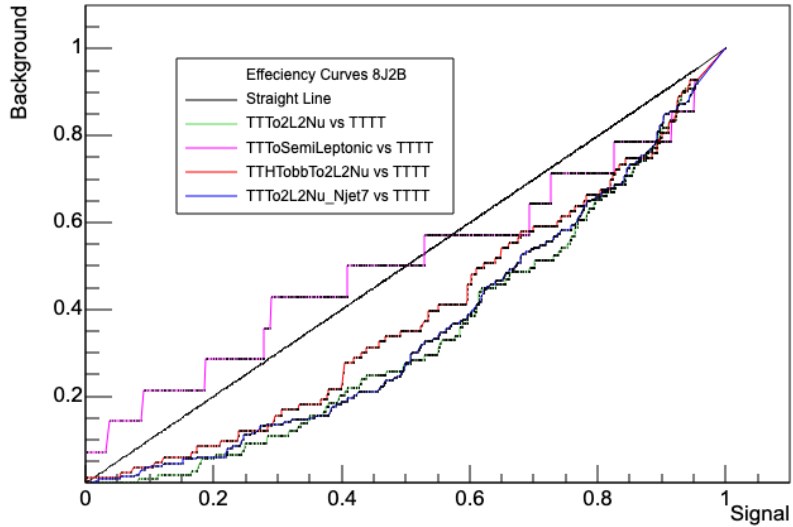
TvsQCD

8J2B Efficiency Curves



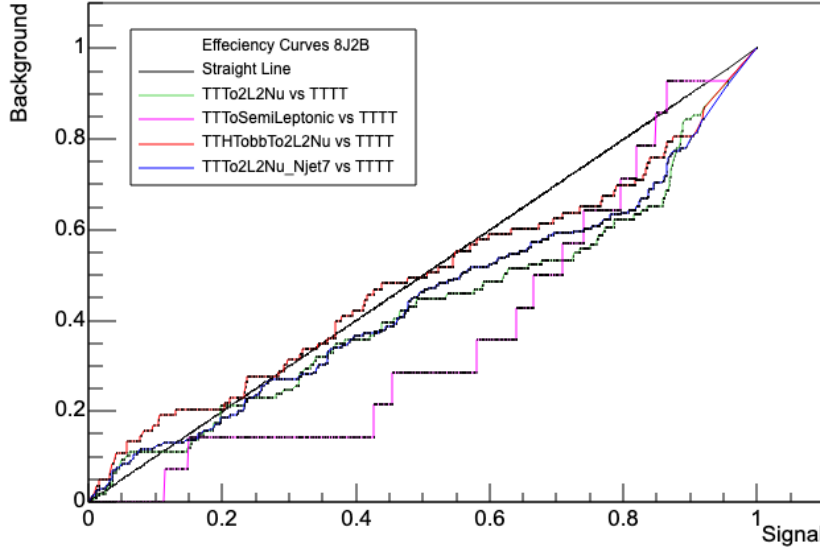
WvsQCD

8J2B Efficiency Curves



HbbvsQVD

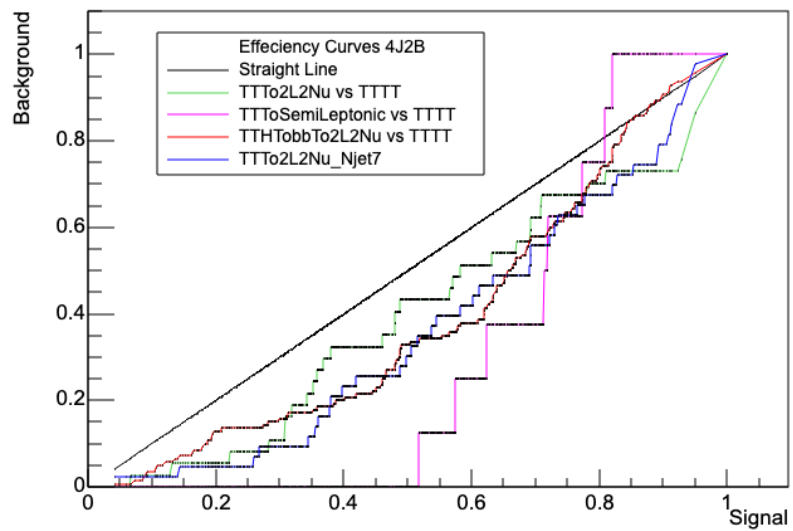
8J2B Efficiency Curves



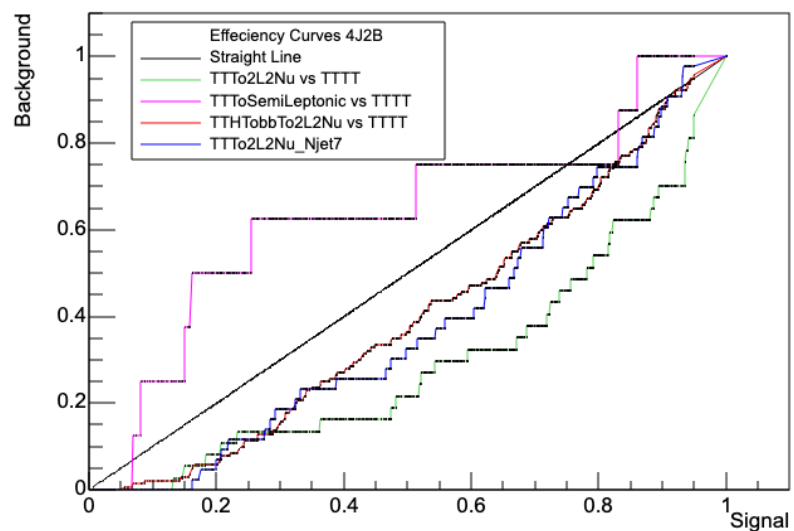
- TTHTo2L2Nu
- TTHTo2L2Nu
- TTHTo2L2Nu\_Njet7
- TTHToSemiLeptonic

# 8J3B

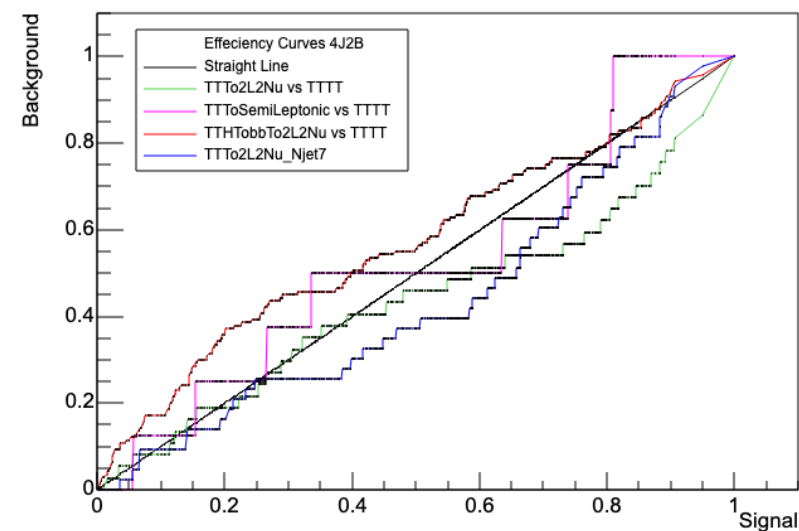
TvsQCD  
8J3B Efficiency Curves



WvsQCD  
8J3B Efficiency Curves



HbbvsQCD  
8J3B Efficiency Curves



THTobbTo2L2NU

TTTo2L2NU

TTTo2L2Nu\_Njet7

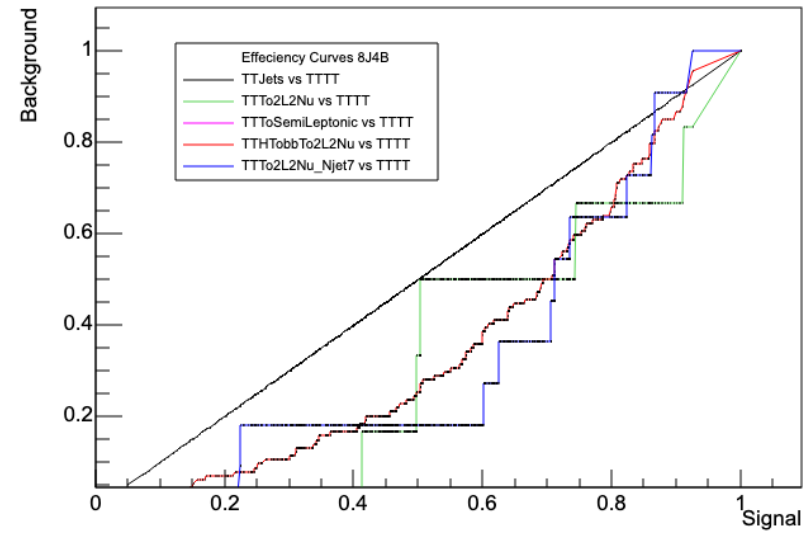
TTToSemiLeptonic



# 8J4B

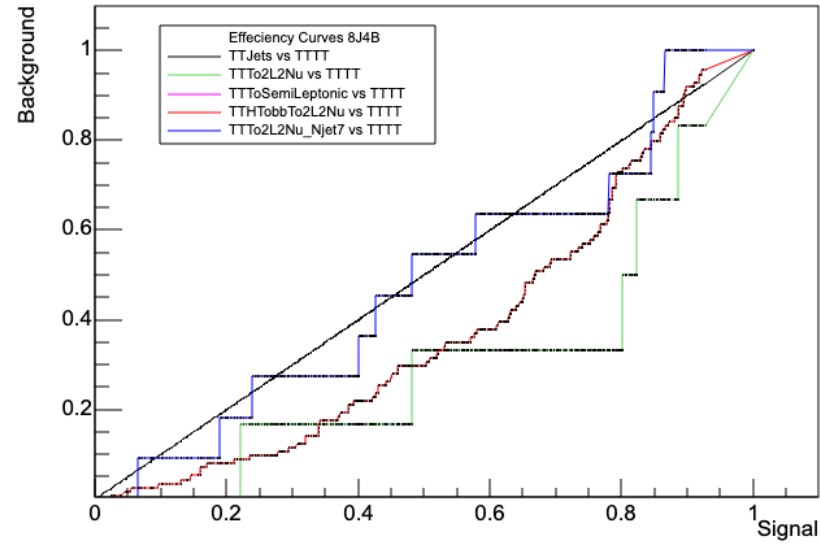
TvsQCD

8J4B Efficiency Curves



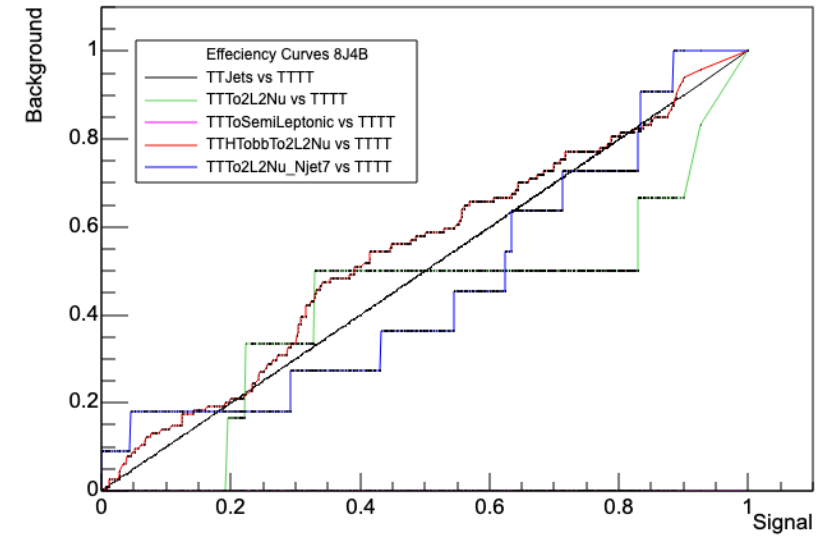
WvsQCD

8J4B Efficiency Curves



HbbvsQCD

8J4B Efficiency Curves



THTobbTo2L2NU

TTTo2L2NU

TTTo2L2Nu\_Njet7

TTToSemiLeptonic

# More about the efficiency curves

- The major point of these curves is to show what's signal-like or background-like.
- By seeing deviations from the straight line we can determine that.
- If the deviations are very close to the straight line then that can't tell us whether the information comes from a signal type event or a background type event.

# What I've learned from this wonderful opportunity

- Things don't go as smoothly as planned.
- Patience and determination is key
- Particle Physics is REALLY interesting.
- I need to practice and further my coding skills
- Have fun and make friends

# What's next for me?

- Visit schools that have accepted me for their graduate school for physics:
  - UM, UC Santa Cruz, & UC Irvine
- Make a decision
- Graduate in the Spring
- Summer project with my graduate advisor
- Go to Japan?

Thank You. I am forever grateful for  
this opportunity.

