Optimizing Trigger Selection for Detection of Doubly Charged Higgs Bosons at the LHC

Rohan Jain

rjain@imsa.edu

Illinois Mathematics and Science Academy

Abstract

In this project, we aim to programmatically find the most efficient triggers for selecting H++ events for application in the Compact Muon Solenoid experiment. Highly efficient triggers are defined as those with high signal efficiency and low background efficiency to give as much signal and as little background as possible. The types of events analyzed were H++, Drell-Yan, and QCD. The initial process started with finding the most efficient triggers on the three sets of events independently, then pairwise comparing the differences, and then finally creating a new figure of merit which was the harmonic mean of all the differences.

Signal

The signal interaction we are searching for is activity of the double charged Higgs boson:

- H++:

Background

Background interactions include the following:

- Quantum Chromodynamics (QCD). QCD interactions are a strong interaction between quarks that are done through gluons.
- Drell-Yan (DY). DY interactions occur when a quark and an antiquark of distinct hadrons annilhate, form a Z-boson, then decay into oppositely charged leptons.

Process

We start by running Monte Carlo data through a trigger simulation, enabling all triggers individually.

- H++
  - Higgs900.txt
    - m of at least 900 GeV
- QCD
  - QCD500-700.txt
    - $\mathrm{H_T}$ between 500-700 GeV
- Drell-Yan
  - DY50.txt
    - m of at least 50 GeV

Preliminary Results

The tables below show the results for the top 5 triggers (highest efficiencies) for each of the three types of events.

Table 1:Trigger Results for H++

Trigger Name	Efficiency
HLT_AK8PFJet40	0.999155
HLT_HcalPhiSym	0.999
HLT_AK4PFJet30	0.99879
HLT_AK4CaloJet30	0.993445
HLT_DiPFJetAve40	0.991245

Table 2:Trigger Results for QCD

Trigger Name	Efficiency
HLT_HcalPhiSym	0.862971
HLT_AK8PFJet40	0.688192
HLT_AK4CaloJet30	0.619257
HLT_AK4PFJet30	0.598404
HLT_PFJet40	0.465758

Redefining Efficiency

Since we need to compare the efficiency of the same trigger across different events, we need to redefine the efficiency of a trigger. So when comparing H++ to any background, we will use the difference of efficiencies across mutual triggers. This can effectively be summarized with the following equation

$$\mathrm{idontremmeberngl}$$

Intermediary Results

The tables below show the results for the top 5 triggers (highest difference in efficiencies) for the pairwise comparisons of the three types of events.

Table 4:Trigger Results for H++ vs. QCD

Trigger Name	Efficiency
HLT_DiPFJetAve320	0.81028139
HLT_PFJet320	0.8088902
HLT_PFMETNoMu110_PFMHTNoMu110_IDTight	0.8054678
HLT_Photon75	0.8039625
HLT_Photon90	0.8035066

Table 5:Trigger Results for H++ vs. DY

Trigger Name	Efficiency
HLT_AK8PFJet140	0.94992018
HLT_DiPFJetAve80	0.9497367
HLT_PFJet140	0.94761912
HLT_PFHT250	0.94691313
HLT_DiPFJetAve140	0.94661373

Redefining Efficiency (pt. 2)

To compare values in the two tables above, we need to redefine efficiency again. This time, we will use the following equation:

$$\mathrm{Efficiency} = \frac{1}{\frac{1}{\mathrm{Eff_{H++vs.QCD}}} + \frac{1}{\mathrm{Eff_{H++vs.DY}}}}$$

Final Results

The tables below shows the (i honestly dont remember)

Table 6:Trigger Results for H++ vs. DY & QCD

Trigger Name	Efficiency
HLT_PFJet320	1.6658838
HLT_Photon75	1.6451807
HLT_AK8PFJet320	1.6429796
HLT_Photon90	1.64207
HLT_DiPFJetAve260	1.632191

Table 7:Trigger Results for H++ vs. DY & QCD

Trigger Name	Harmonic Mean $/ \mathrm{n}$
HLT_PFJet500	9591.97113454199
HLT_CaloJet500_NoJetID	9304.47172437449

Questions

Next Steps

Conclusions