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

Rohan Jain   Dr. Peter J. Dong

rjain@imsa.edu   pdong@imsa.edu

Illinois Mathematics and Science Academy

Signal

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

- H++: The doubly charged Higgs boson is our signal and is a hypothetical particle that we believe exists and are therefore trying to prove its existence within Monte Carlo events.

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++
  - m of at least 900 GeV
- QCD
  - H_T between 500-700 GeV
- Drell-Yan
  - 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

Best Electron Trigger: HLT_Ele8_CaloIdL_TrackIdL_IsoVL_PFJet30 | 0.83359

Best Muon Trigger: HLT_Mu8_TrkIsoVVL | 0.78888

Preliminary Results (cont.)

Table 2:Trigger Results for QCD

Trigger Name	Efficiency
HLT_HcalPhiSym	0.862971
HLT_AK8PFJet40	0.688192
HLT_AK4CaloJet30	0.619257

Best Electron Trigger: HLT_Ele8_CaloIdM_TrackIdM_PFJet30 | 0.0633013

Best Muon Trigger: HLT_Mu3_PFJet40 | 0.277873

Table 3:Trigger Results for DY

Trigger Name	Efficiency
HLT_HcalPhiSym	0.884871
HLT_AK8PFJet200	0.882028
HLT_HT425	0.872316

Best Electron Trigger: HLT_Ele20_WPLoose_Gsf | 0.217682

Best Muon Trigger: HLT_L1SingleMu18 | 0.277113

Intermediary Results

The tables below show the results for the top 5 triggers for the pairwise comparisons. Efficiency is now the differenc between signal and background efficiencies.

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

Best Electron Trigger: HLT_Ele12_CaloIdL_TrackIdL_IsoVL_PFJet30 | 0.7971663

Best Muon Trigger: HLT_IsoMu20 | 0.75249405

Intermediary Results (cont.)

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

Trigger Name	Efficiency
HLT_AK8PFJet140	0.94992018
HLT_DiPFJetAve80	0.9497367
HLT_PFJet140	0.94761912

Best Electron Trigger: HLT_Ele50_CaloIdVT_GsfTrkIdT_PFJet165 | 0.79523

Best Muon Trigger: HLT_Mu15_IsoVVVL_PFHT600 | 0.742399778

Final Results

The tables below shows the sum of pairwise compared efficiencies. It is now calculated as the sum of the previous two efficiencies.

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

Trigger Name	Efficiency
HLT_PFJet320	1.6658838
HLT_Photon75	1.6451807
HLT_AK8PFJet320	1.6429796

Best Electron Trigger: HLT_Ele50_CaloIdVT_GsfTrkIdT_PFJet165 | 1.58410567

Best Muon Trigger: HLT_Mu15_IsoVVVL_PFHT600 | 1.4755256380000001

Questions

- Why do photon triggers perform so well?
- How do we optimize using multiple triggers at once?

Conclusions

By the process of comparing various triggers against each other and on different types of Monte Carlo events, we have narrowed down our selection of triggers to a few of the most efficient, which can be found in the ”Final Results” section.

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