Final Presentation

Measuring the efficiency of a Higgs decay to tau-tau

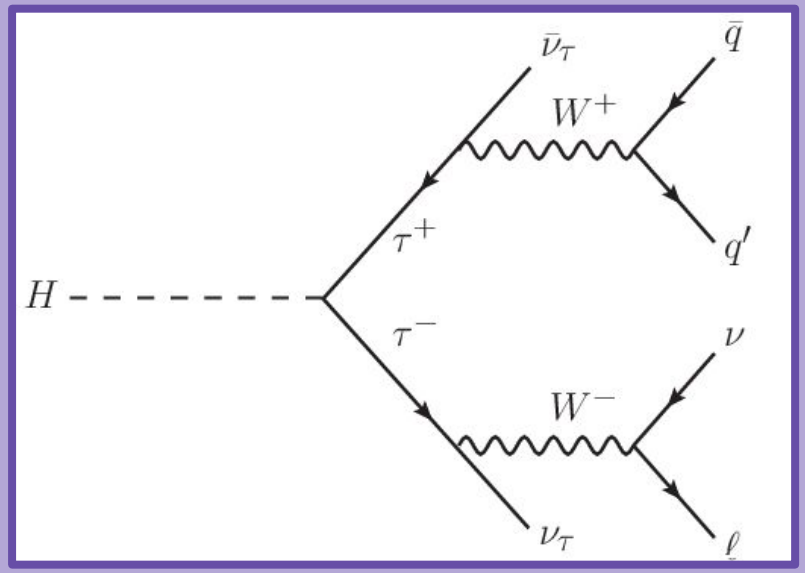
Mentee: Rosalie Williams (California State Polytechnic University - Pomona)
Mentor: Isobel Ojalvo (Princeton)

Overview

- Theoretical background:
  - Higgs ->Tau Tau
  - Higgs production
- Trigger system overview
- Control Plots
- Efficiency Measurement

Higgs Decay to Tau Tau

- High probability of decay to tau leptons
- Can decay leptonically or hadronically
  - Decaying to hadrons look like jets
- Boosted topologies
  - Heavy to light decay causes high momentum, called “boosted”
  - Angle of decay for the smaller particle is small, measured in η and Φ



Info on Tau Decays

- Tau Decays:
  - Dominantly decays hadronically ~64.79% of the time
  - Can decay leptonically

- Boosted topologies
  - Heavy to light decay causes high momentum, called “boosted”
  - Angle of decay for the smaller particle is small, measured in η and Φ

Higgs Decay to Tau Tau

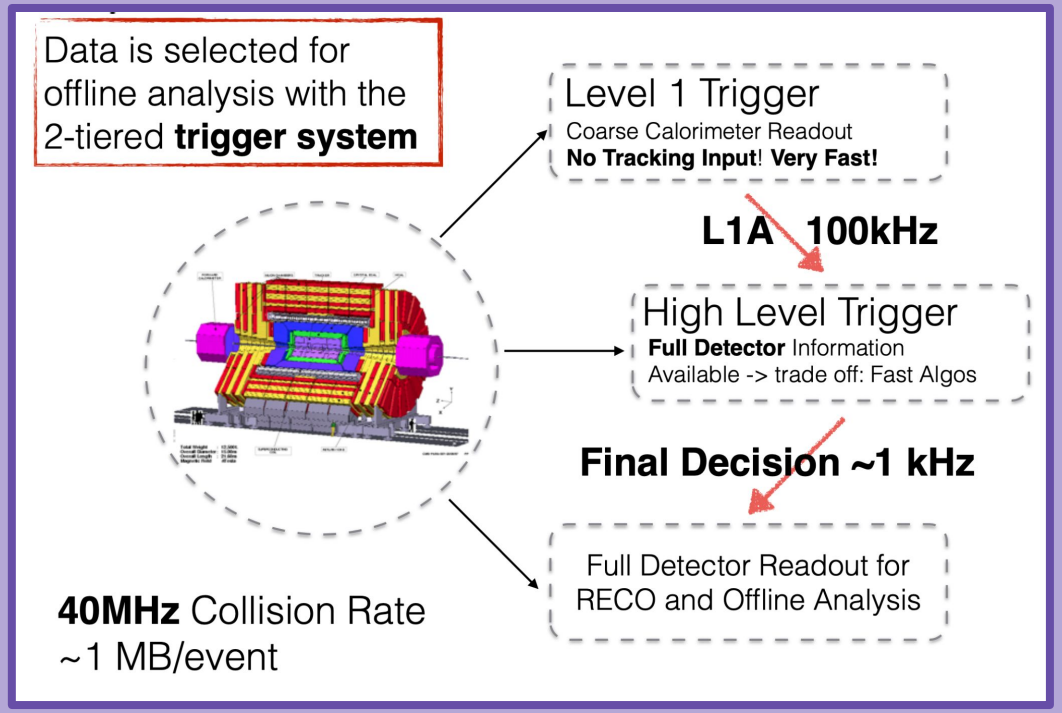
- Tau Leptons:
  - Reconstructing taus is difficult due to its decay
  - Neutrinos not measured by CMS

- Goal: How can we ensure we collect Higgs to tau tau signal?

Decay channel	Branching ratio	Rel. uncertainty
$H \to \gamma\gamma$	2.28×10^{-3}	$^{+5.0\%}_{-4.9\%}$
$H \to ZZ$	2.64×10^{-2}	$^{+4.3\%}_{-4.1\%}$
$H \to W^+W^-$	2.15×10^{-1}	$^{+4.3\%}_{-4.2\%}$
$H \to \tau^+\tau^-$	6.32×10^{-2}	$^{+5.7\%}_{-5.7\%}$
$H \to b\bar{b}$	5.77×10^{-1}	$^{+3.2\%}_{-3.3\%}$
$H \to Z\gamma$	1.54×10^{-3}	$^{+9.0\%}_{-8.9\%}$
$H \to \mu^+\mu^-$	2.19×10^{-4}	$^{+6.0\%}_{-5.9\%}$

Trigger System

- L1 Trigger selects high transverse momentum events and missing transverse energy
  - Performs online event selection
- We use the L1 Trigger and the High Level detector to examine the efficiency of this process

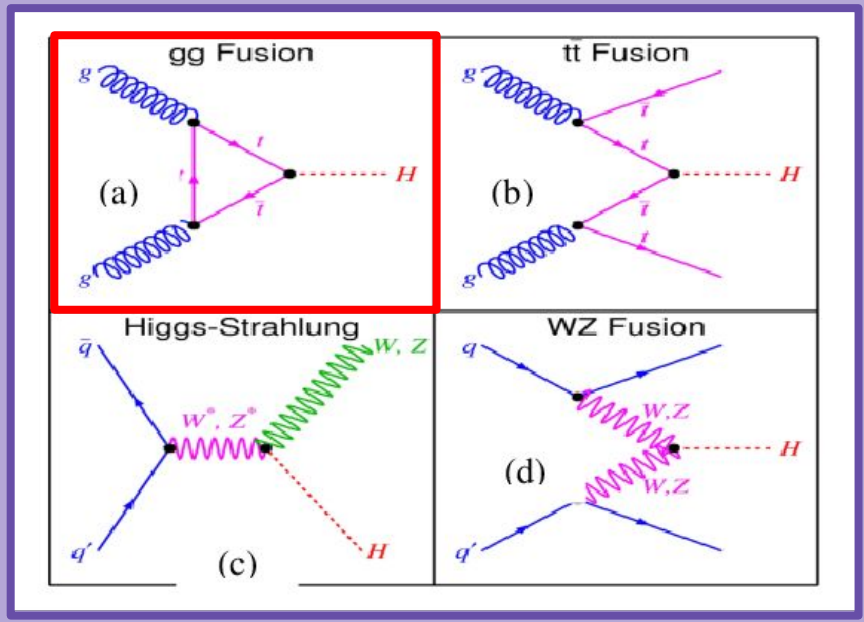


ggH -> tautau

(Gluon fusion production of the Higgs, decays to two b-quarks)

- Collider produces gluons
- One of six processes to produce Higgs
- Gluon fusion most likely to produce Higgs

Diagram on the right shows various ways to produce a Higgs



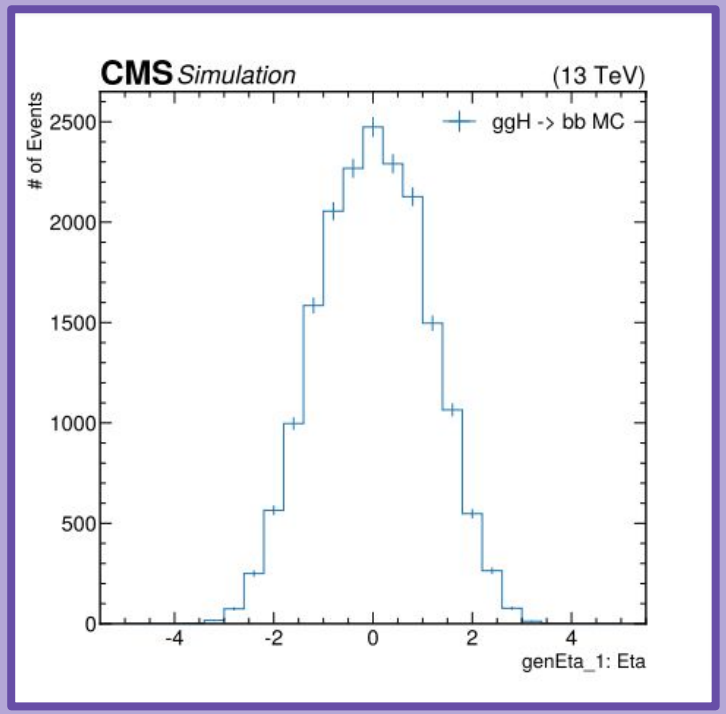
Plots

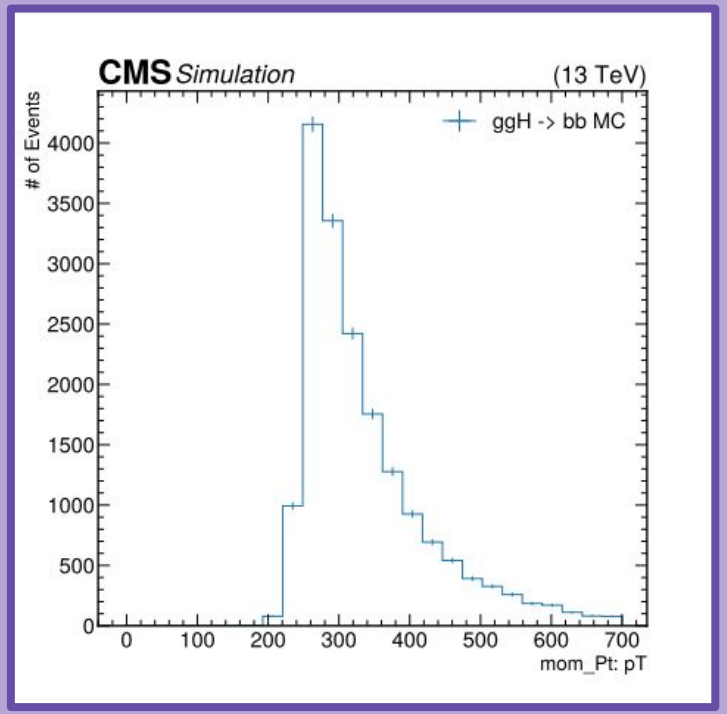
- Made in PyROOT
- Multiple elif statements to change formatting for certain types of datasets
- Value cuts

Example code creating plots labeled “Eta”:

```
i=0
plt.style.use(hep.style.CMS)
for i in range(len(tree)):
    aspect = tree[i]
    array1 = aspect.array()

    h = hist.Hist(hist.axis.Regular(25, -5, 600, label=str(aspect.name)))
    plt.xlabel(str(aspect.name), fontsize = 20)
    hep.cms.label()
    plt.ylabel('# of Events', fontsize = 20)

    if "Eta" in aspect.name:       #formatting Eta plots
        if "recoEta" in aspect.name: #applying cuts
            h = hist.Hist(hist.axis.Regular(25, -5, 5, label=str(aspect.name)))
            plt.xlabel((str(aspect.name)+': Eta'), fontsize = 20)
            particle_cut = (array1 < 2.1) #need Eta values < 2.1
            h.fill(particle_cut)   #plotting those that passed the cut

            hep.histplot(h, label = "ggH -> bb MC")
            plt.legend()           #adds legend
```

Plot Examples





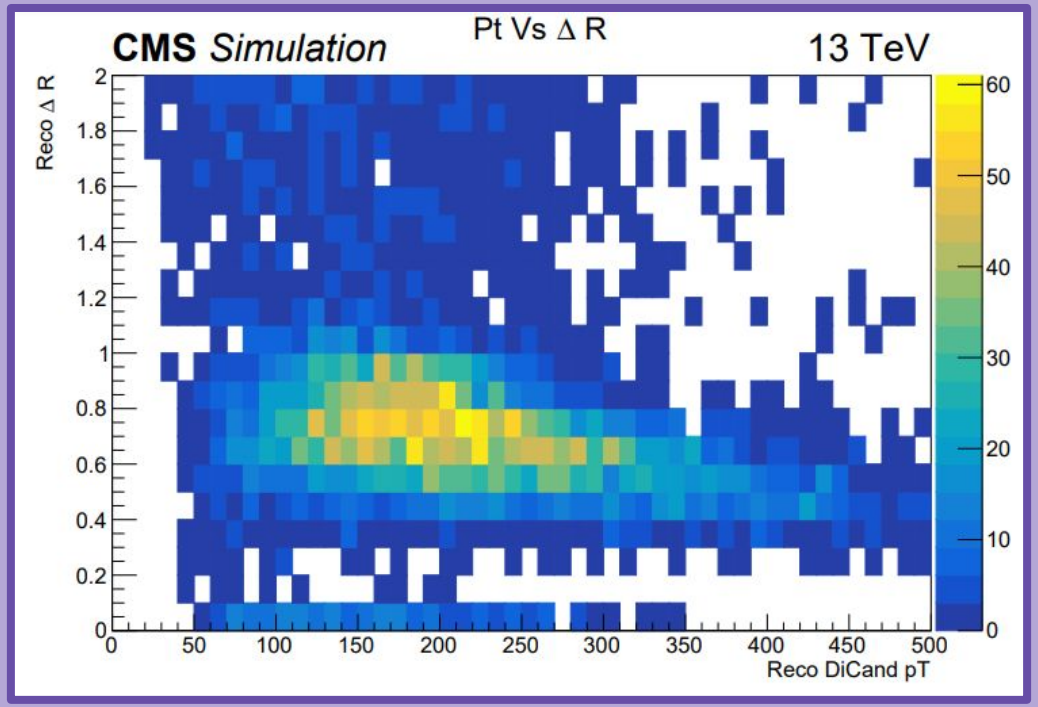
2D Plot

- A 2-dimensional histogram made with recoDiCand P_T and reco ΔR

Example code:

```
Plot = ROOT.TH2F("recoDiCandPt", "recoDR", 50, 0, 500,20,0,2)

for treeIndex in tqdm(range(Tree.GetEntries())):

        Tree.GetEntry(treeIndex)
        Plot.Fill(Tree.recoDiCandPt,Tree.recoDR)

Canvas = ROOT.TCanvas("theCanvas")

Plot.Draw("COLZ")
ROOT.gStyle.SetOptStat(0)
```

2D Final Plot



Made with help from Dr. Andrew D. Loeliger

Efficiency Plots

What is an Efficiency Plot?

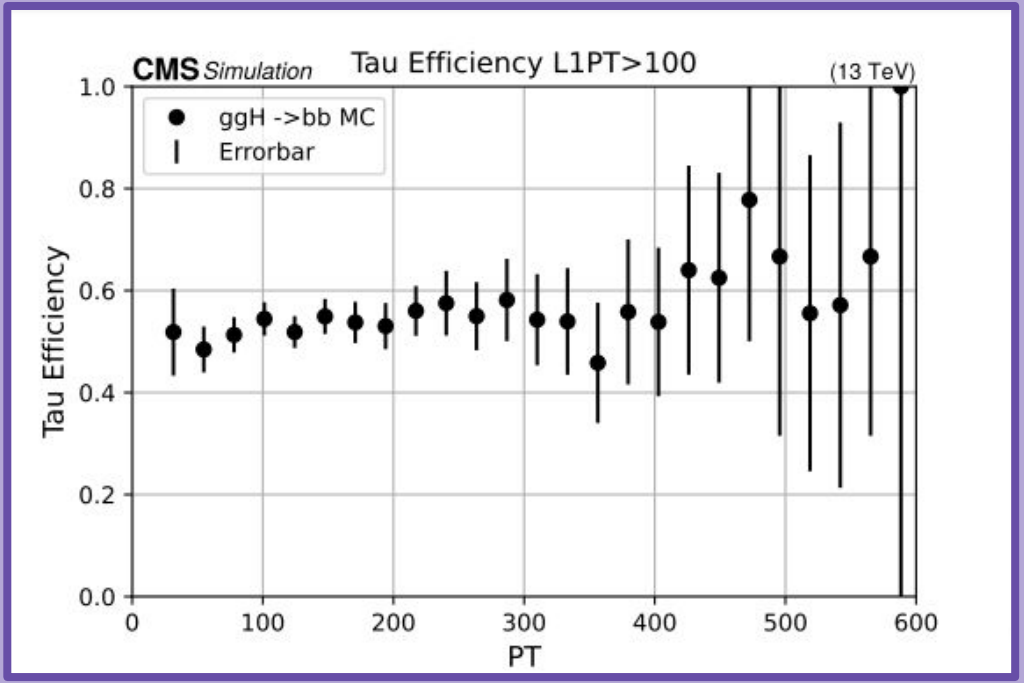
- Measures how the level 1 trigger compares to the rest of the detector
- Measuring events made by the ggH -> bb MC

Efficiency = (# of Level 1 taus that pass our Level 1 criteria) / (# of genuine taus)

- “Genuine” taus are taus that are reconstructed by the rest of the detector
- The goal is to see how effective the trigger is at selecting genuine taus

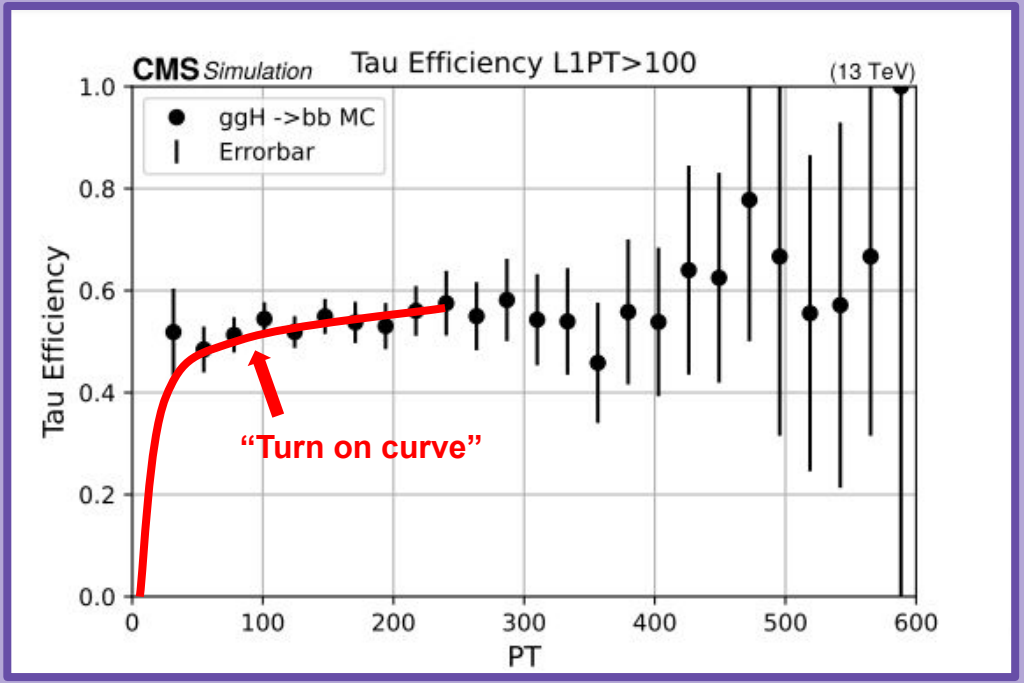
Efficiency Measurement

- Selection of recoP_T>0 GeV and L1P_T>100 GeV



Efficiency Measurement

- Selection of recoP_T>0 GeV and L1P_T>100 GeV
- Should see a “turn on curve” around 0



End

Questions,

Comments,

Concerns?