Studies on resolved and boosted overlaps in the HH to bbtautau processes

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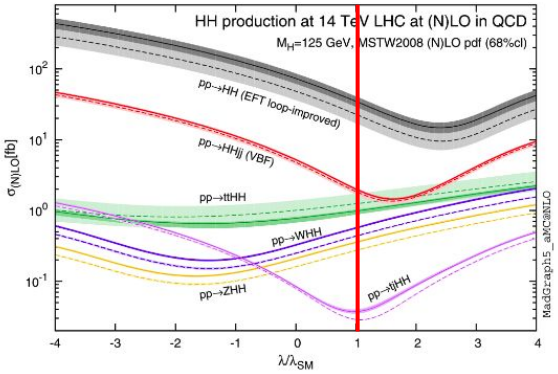
Relevance of studying HH pair production

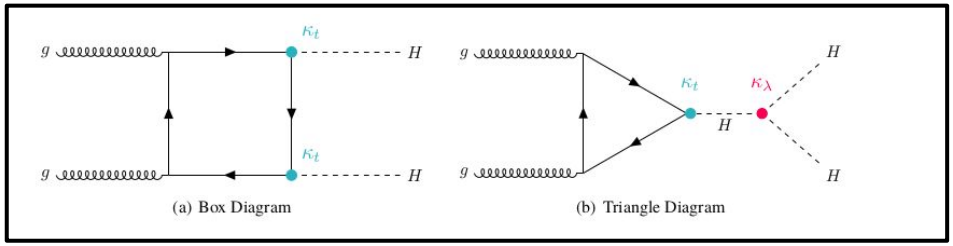
Relevance:

- Higgs self-coupling and its relation with the shape of the Higgs Potential.
- The electroweak symmetry breaking mechanism.

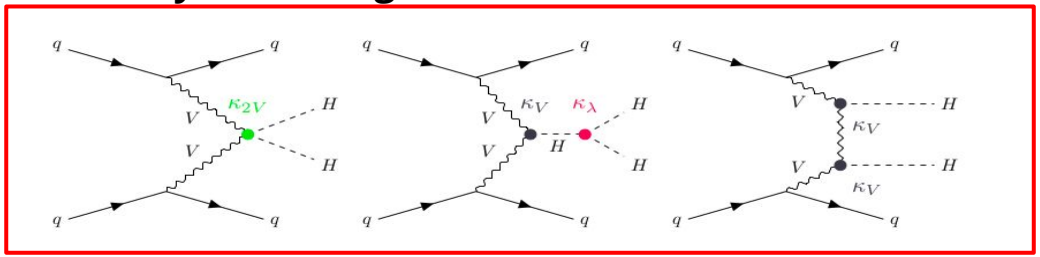
Dominant HH pair Production Modes



ggF Feynman Diagrams:



VBF Feynman Diagrams:



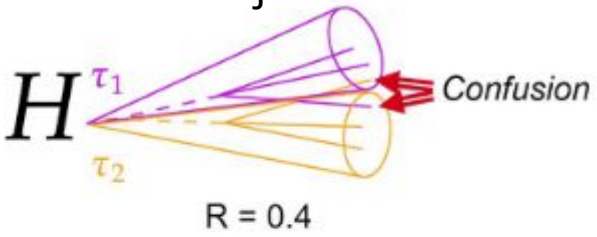
Resolved and Boosted Regimes

Regimes:

- **Resolved**: pT < 200 GeV
  - Clear identification of single jets (b or tau)

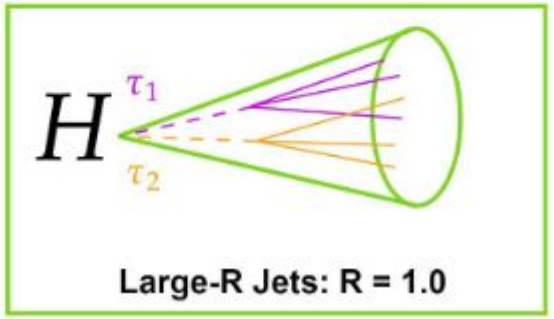
Boost

- **Boosted**: High pT
  - Collimated decay products
  - Reconstruct two bb or two tau as fat jets



Challenges with traditional jet reconstruction:

- Hard to identify b or tau jets in the boosted regime



Introduction

General Objective

Find a good definition of boosted bb and tautau jet based on substructure variables and define a baseline to understand the number of (semi)boosted events and the overlap with the resolved selections.

Available Resources

- Easyjet framework
  - Run all of the standard resolved selections stored as event flags + run the UFO jets overlap removal.
- RUN 2 MC samples for 3 different campaigns (each one for each year of data-taking)
  - Simulated data for two main production modes:
    - ggF HH
    - VBF HH

Procedure to identify boosted jets

Now, the idea is to use the output files given by the easyjet framework, create our own boosted analysis and separate the events into 4 main classes.

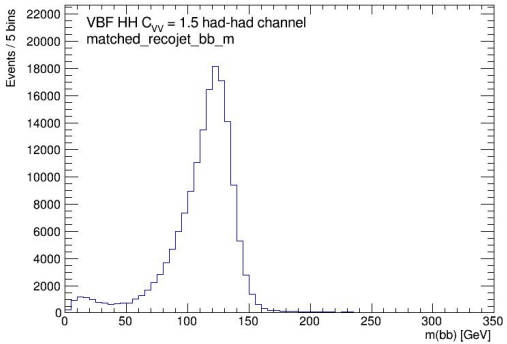
- R_bb R_tautau
- R_bb B_tautau
- B_bb R_tautau
- B_bb B_tautau

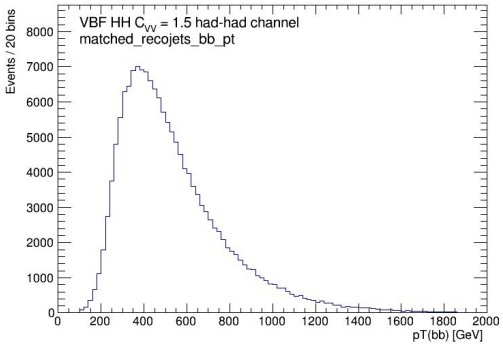
This classification is done through a matching process between truth objects and reconstructed jets.

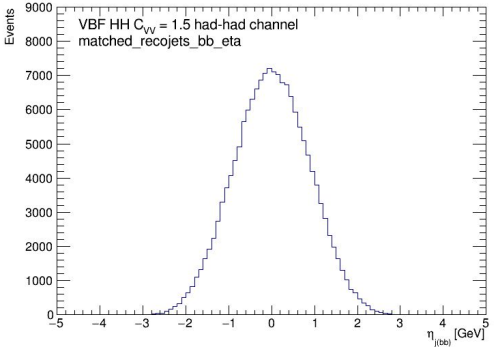
Procedure

1. Identification of truth objects (truth b1/b2/tau1/tau2).
2. Matching between truth objects and fatjets (jets ak10 UFO).
3. Definition of the main 4 classes (RR, RB, BR and BB).

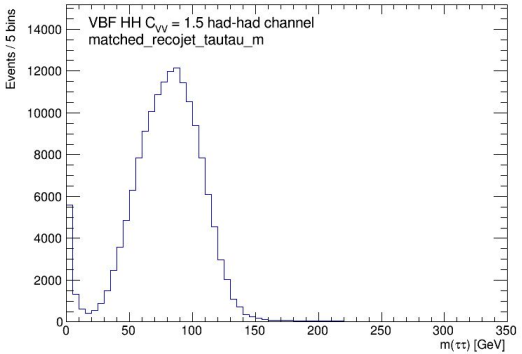
Benchmarks of the matching process

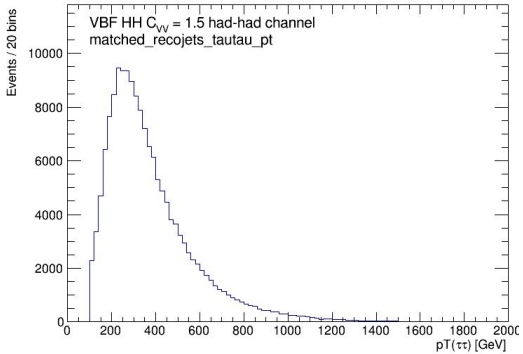


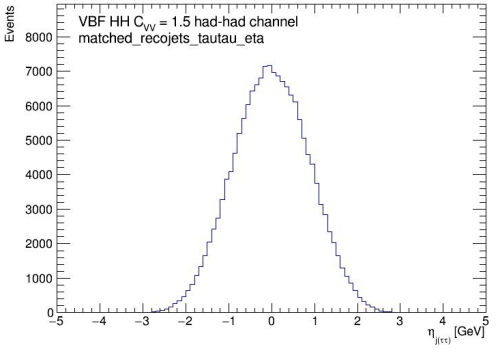




Mass of the boosted jets.
pT distribution.
Eta distribution.
Others.

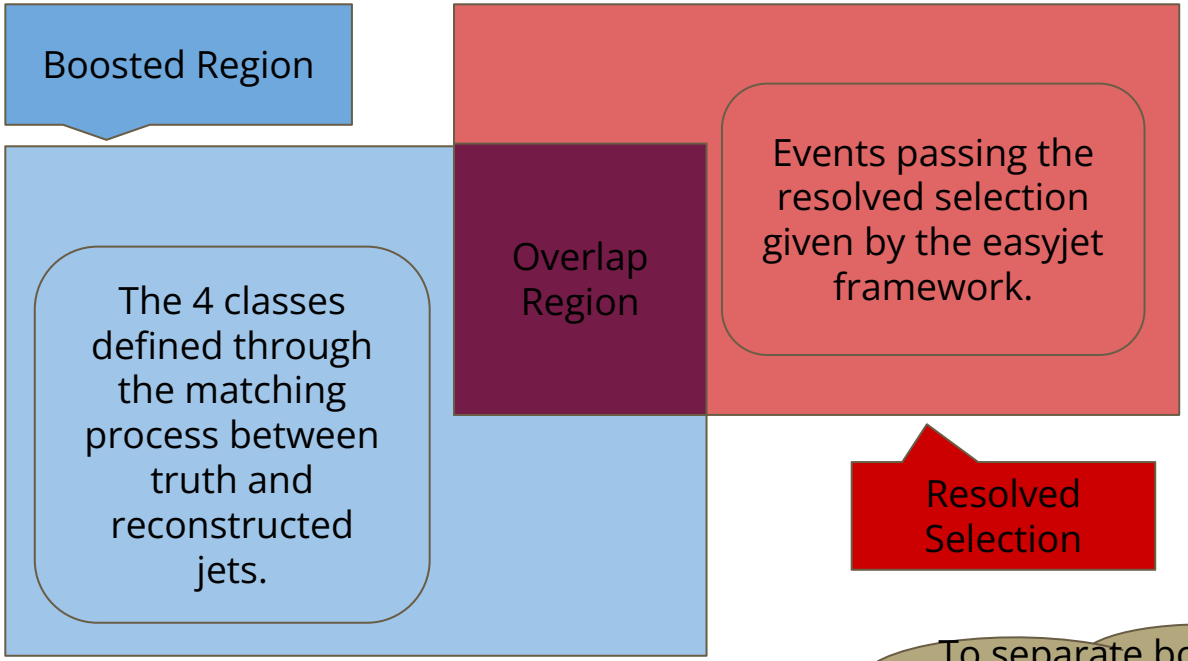






All seem to be fine!

Overlap regions description



Overlap Region

Events that are categorized in the resolved selection having boosted jets - A jet can be reconstructed at the same time as both small and large radius jets.

To separate boosted and resolved events we should rather try to act on the jets themselves and not on the event

Definition of ratios plots

- **Fraction r1:**

  h_r1 = number_of_events_in_overlap_region/number_of_events_in_resolved_selection

- **Fraction r2:**

  h_r2 = number_of_events_in_overlap_region/number_of_events_in_boosted_analysis_class

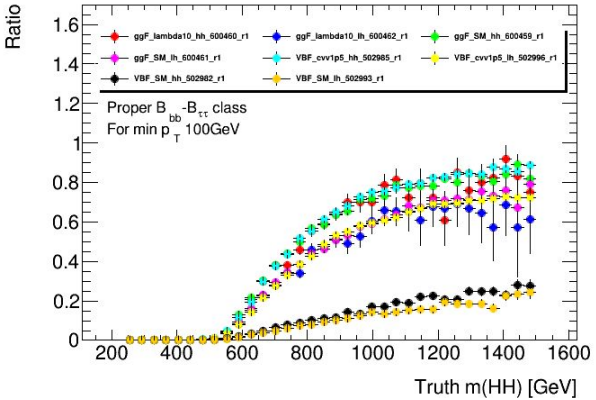
- **Fraction r3:**

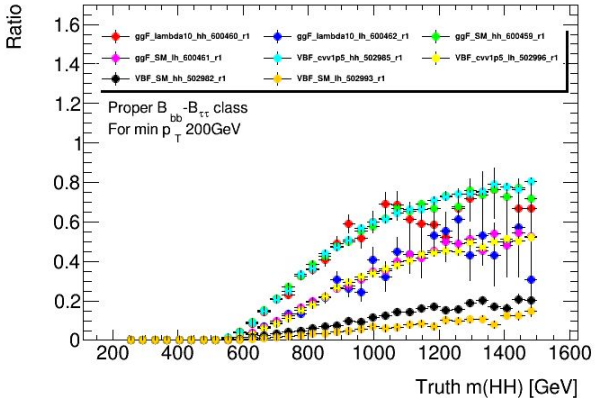
  h_r3 = number_of_events_in_resolved_selection/all_events

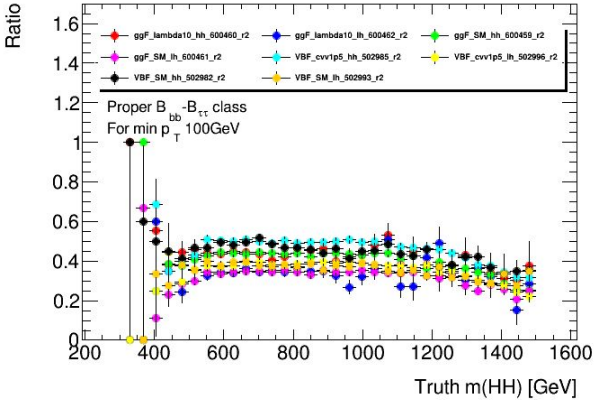
- **Fraction r4:**

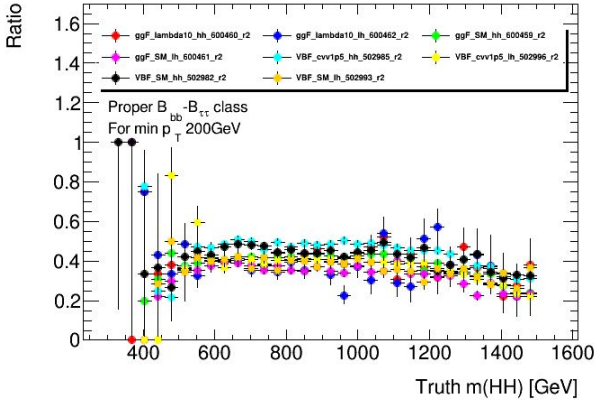
  h_r4 = number_of_events_in_a_certain_boosted_analysis_class/all_events

Ratio plots for truth mHH - r1 and r2









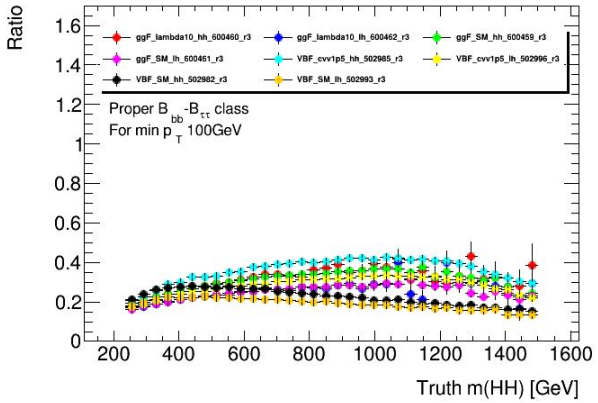
Ratio r1:
events overlap region / # events resolved selection

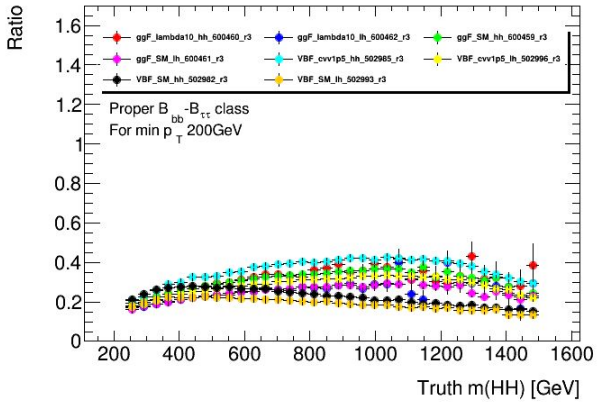
Ratio r2:
events overlap region / # events B_bb-B_tautau class

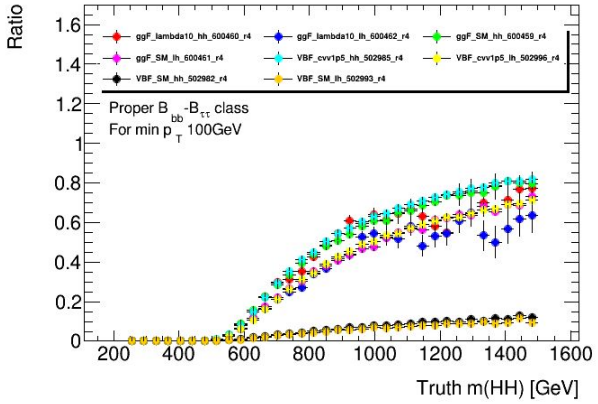
(a) min_pT > 100 GeV

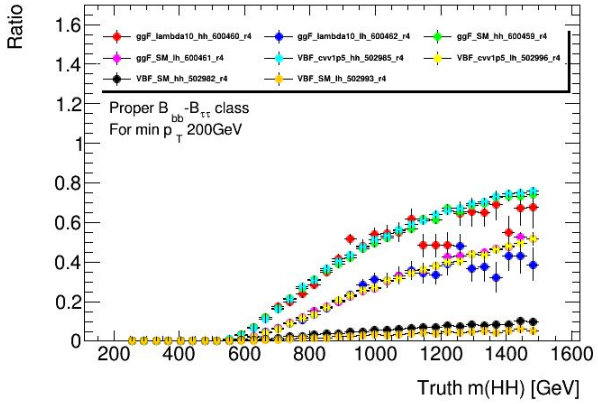
(b) min_pT > 200 GeV

Ratio plots for truth mHH - r3 and r4









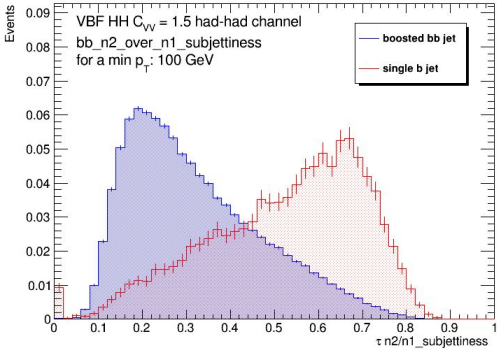
Ratio r3:
events resolved selection / all events

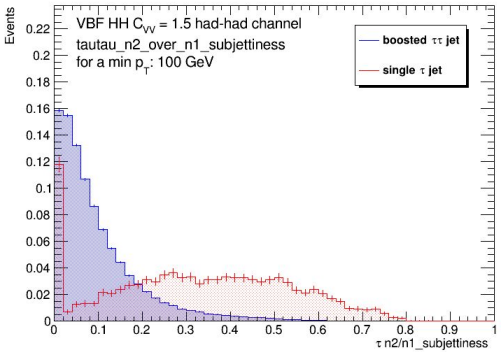
Ratio r4:
events B_bb-B_tautau class / all events

(a) min_pT > 100 GeV

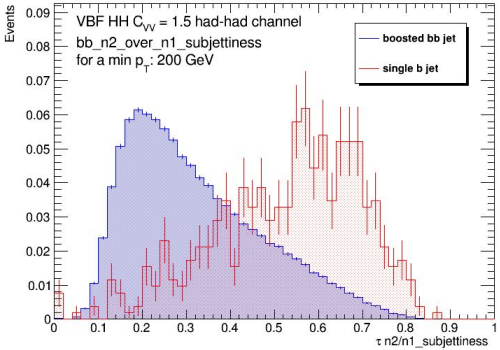
(b) min_pT > 200 GeV

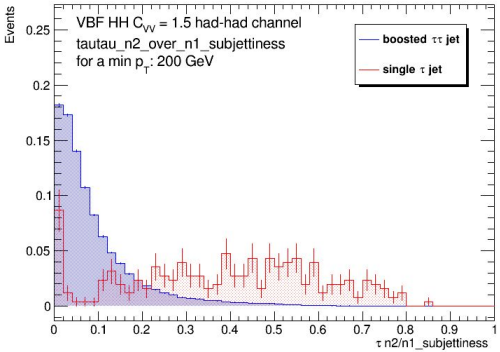
VBF had-had channel (Cvv = 1.5) - n_subjettiness



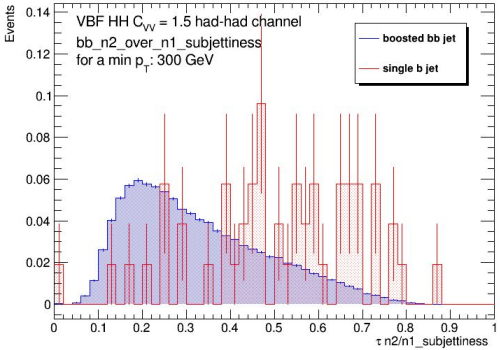


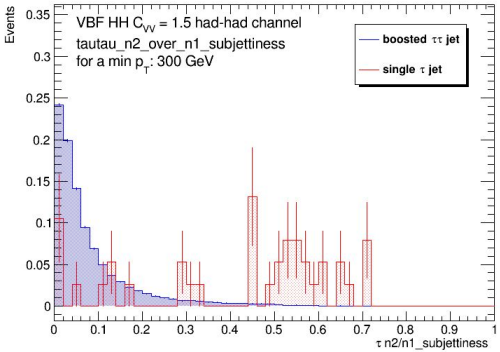
(a) min_pT > 100 GeV





(b) min_pT > 200 GeV





(c) min_pT > 300 GeV

Distribution of n2/n1 n-subjettiness: ratio between the branches **recojet_antikt10UFO_Tau2_wta** (n2 subjettiness) and **recojet_antikt10UFO_Tau1_wta** (n1 subjettiness).

Thanks!