Higgs self-coupling analysis with H→WW*

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Status

- Continue to update LCFIPlus
  - Embedding AVF is done
  - Embedding BNess tagger is partially done
  - Start to check the result

- Trying an idea for better jet clustering
  - Single jet clustering will make misclustering in some events
  - Integrating the results of some clustering methods might improve jet clustering
  - In Machine Learning field, there seems some improvement using "cluster ensemble"

  - So, we can try cluster ensemble for jet clustering
  - Can we obtain better result??

Method for cluster ensemble

- A jet clustering makes partitions for mini-jets
  - Generally, partition of each jet clustering is different
  - e.g.) 3 jet clustering for 7 mini-jets:

	$\mathbf{H}^{(1)}$			$\mathbf{H}^{(2)}$			$\mathbf{H}^{(3)}$			$\mathbf{H}^{(4)}$	
	$\mathbf{h}_1$	$\mathbf{h}_2$	$\mathbf{h}_3$	$\mathbf{h}_4$	$\mathbf{h}_5$	$\mathbf{h}_6$	$\mathbf{h}_7$	$\mathbf{h}_8$	$\mathbf{h}_9$	$\mathbf{h}_{10}$	$\mathbf{h}_{11}$
v_1	1	0	0	0	1	0	1	0	0	1	0
v_2	1	0	0	0	1	0	1	0	0	0	1
v_3	1	0	0	0	1	0	0	1	0	0	0
v_4	0	1	0	0	0	1	0	1	0	1	0
v_5	0	1	0	0	0	1	0	0	1	0	1
v_6	0	0	1	1	0	0	0	0	1	0	0
v_7	0	0	1	1	0	0	0	0	1	0	0

H(i): clustering method

h_i: partition

v_i: mini-jet

  - Making consensus partition from those different clustering methods
  - Need to define objective function to obtain the consensus partition
    - There are some formulation of objective function
    - I tried some objective functions → in most ways, the results are very unstable…

Objective function for cluster ensemble

- Mutual information approach:

$$\phi^{(\mathrm{NMI})}(\lambda^{(a)}, \lambda^{(b)}) = \frac{2}{n} \sum_{\ell=1}^{k^{(a)}} \sum_{h=1}^{k^{(b)}} n_{\ell}^{(h)} \log_{k^{(a)} \cdot k^{(b)}} \left(\frac{n_{\ell}^{(h)} n}{n^{(h)} n_{\ell}} \right)$$

$\lambda^{(a)}, \lambda^{(b)}$: a cluster of different clustering method

$k^{(a)}, k^{(b)}$: num. of clusters of each clustering method

$n_l^{(h)}$: num. of mini−jets which belong to both of the cluster $\lambda^{(a)}$ and $\lambda^{(b)}$

$n^{(h)}$: num. of mini−jets which belong to cluster $\lambda^{(a)}$

n_l: num. of mini−jets which belong to cluster $\lambda^{(b)}$

n: total number of mini−jets

- Maximize average mutual information:

$$\phi^{(\mathrm{ANMI})}(\boldsymbol{\Lambda}, \hat{\lambda}) = \frac{1}{r} \sum_{q=1}^{r} \phi^{(\mathrm{NMI})}(\hat{\lambda}, \lambda^{(q)}).$$

Λ: consensus partition

$\hat{\lambda}$: a cluster of consensus partition

$\lambda^{(q)}$: a cluster of each clustering method

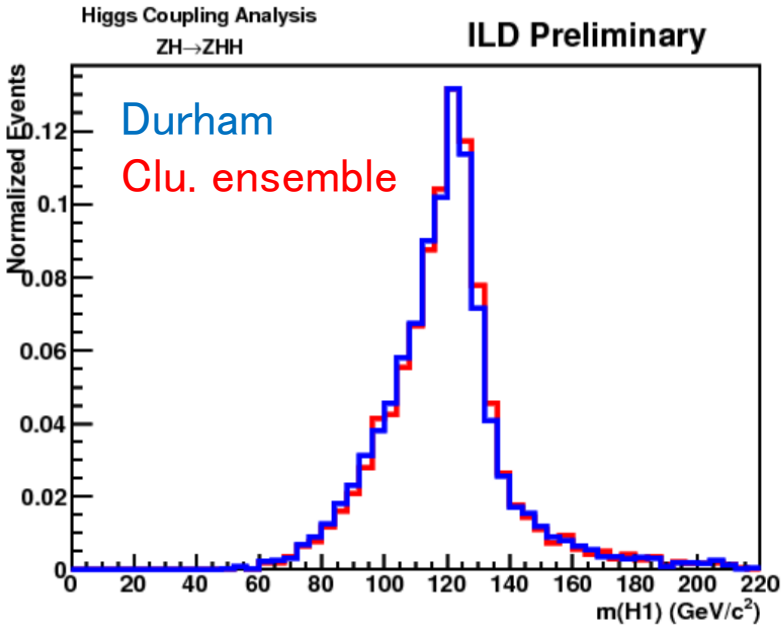
- Global maximum is the best, but it is difficult to get it
  - It takes much CPU time
  - Instead that, looking for local maximum starting from certain clustering method

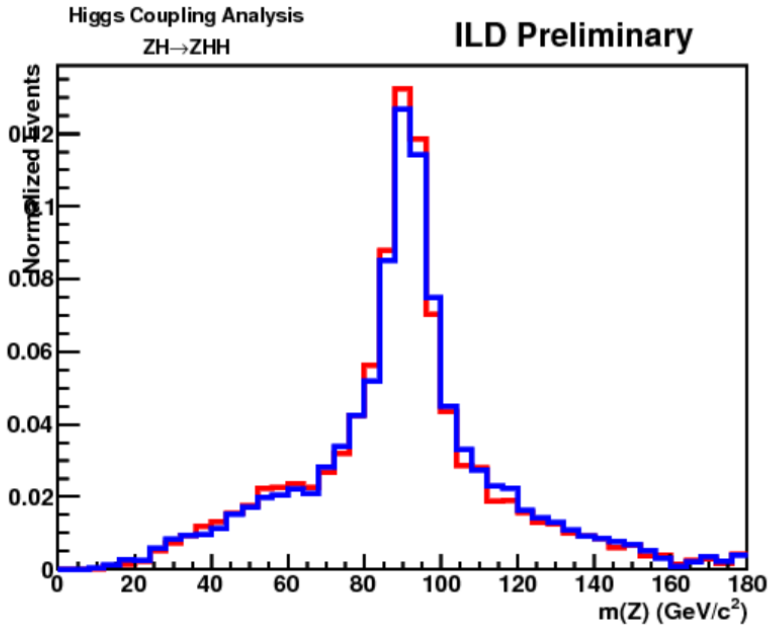
TRIAL

- Using 6 kinds of different clustering methods:
  - Durham, Jade, Geneva, LUCLUS, Kt, and Cambridge
  - Anti-Kt was not good…
- Sample: qqHH@500GeV, trying 6 jet clustering
- First, Durham clustering is performed until constructing 30 mini-jets
- From 30 mini-jets, those 6 clusterings are performed and get the partitions
- Trying to obtain consensus partition using mutual information approach
  - Starting from each jet clustering partition, making average mutual information maximum by changing cluster of each mini-jet one by one
- Get final jet clustering using consensus partition

First trial

- qqHH→(qq)(bb)(bb): check Higgs and Z mass
- Loose b-tagging is imposed: btag>0.35 for all the bjet candidates
- MC Truth direction matching of jets is performed:
- Mass distribution:





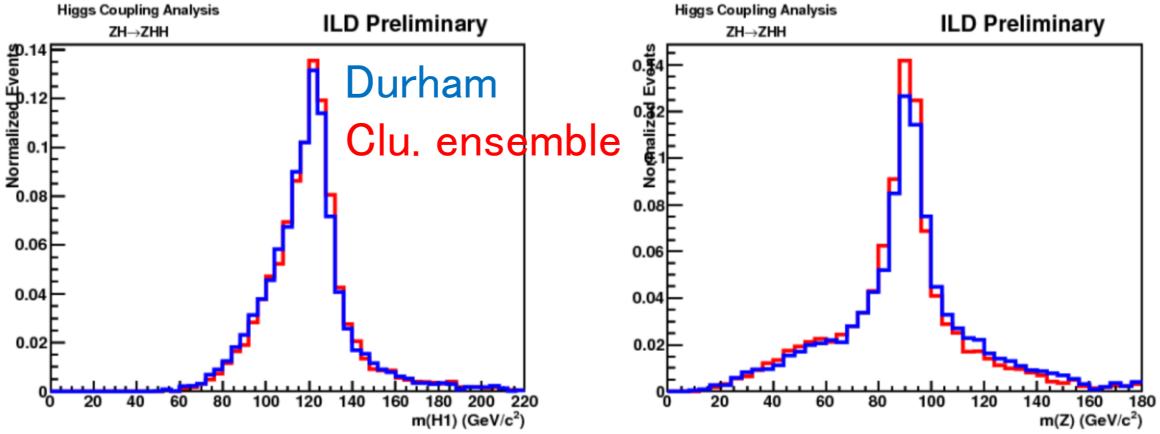
- Num. of good events with truth matching:

method	Durham	Clu. ensemble
Num. of good event	3779	3664

- Due to flavor tagger? Need to check without flavor tagging…

NEED MORE IDEA

- Clu. Ensemble is going in good direction about mass dist.
  - But the result is not enough
  - need more idea…
- Higgs mass difference is slighter than Z mass difference
  - Why?
  - Vertex?
- For trial, I permit merging of jets with vertex
  - In nominal way, merging jets with vertices is almost forbid



  - Going better – Is there better way of vertex jet treatment??