



STUDY OF THE POSSIBILITY OF ATTACHING PI0S TO VERTICES AND AN EXTRA

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- Constructing π^0 vertex finder
 - How to
 - Some results
 - Todos

- An extra
 - Quick& poor study for the future study



CONSTRUCTING π^0 VERTEX FINDER FOR VERTEX MASS IMPROVEMENT

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INTRODUCTION

○ For flavor tagging improvement

- Vertex mass is the key to separate heavy/light flavor vertex
- Many π^0 s will escape from B/D vertex \rightarrow checked that using MC truth
- Mass resolution will be degraded due to escaping neutrals
- Is there possibility to recover π^0 s which escape from vertices?

○ Building π^0 finder – many components are necessary

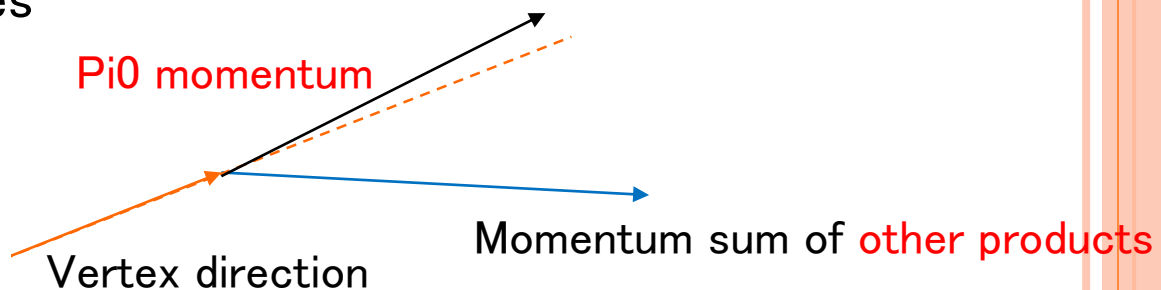
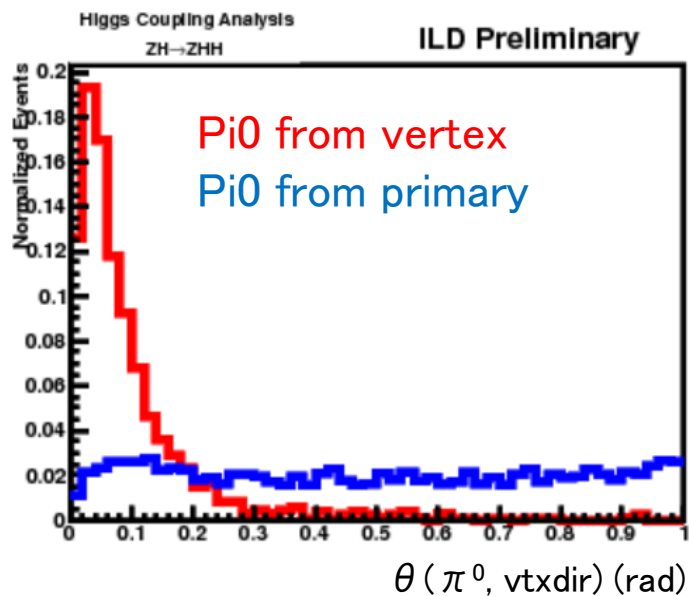
- Gamma finder – using shower profile in calorimeters
- π^0 finder – solving gamma pairing
- **Vertex finder – which vertex is the π^0 coming?**

○ Last step is to attach π^0 s to the vertex – find vertex of π^0 s

- Very difficult to identify vertex – depends on detector configuration
- Making the best of decay kinematics
- Using TMVA to find π^0 candidates from the vertex
- Comparing vertex mass distribution
- Sample: using qqHH@500GeV samples (so many tracks & π^0 s in events)

KEY ISSUES

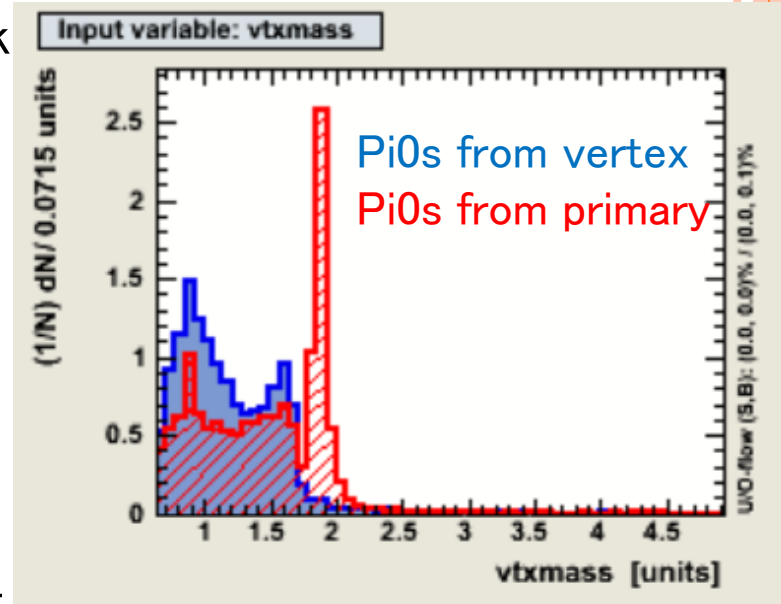
- Pi0s from (secondary, thirdary) vertices are very collinear to vertex direction
 - due to their small masses



- But, there are many pi0s which come from primary vertex & are accidentally collinear to the vertex direction!
 - Ref.) In qqHH events, 50~60 pi0s will be produced!!

KEY ISSUES

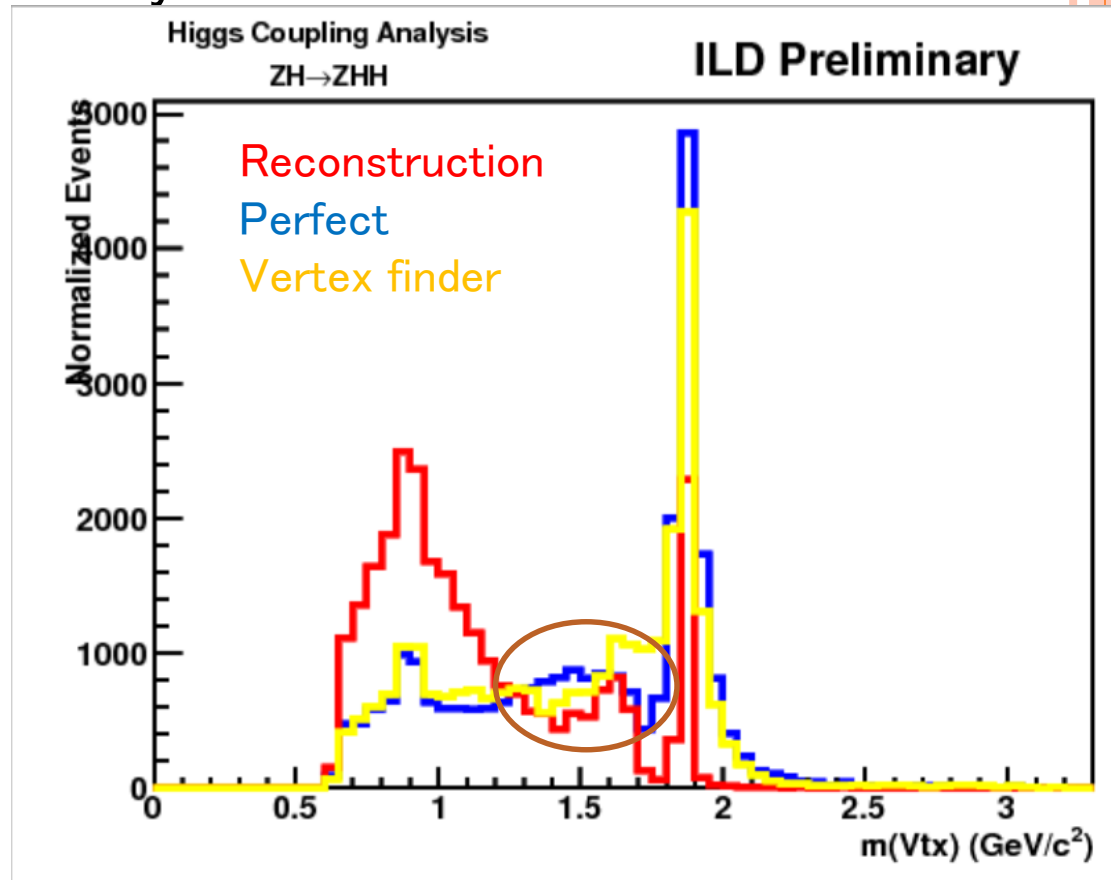
- To avoid attaching too many pi0s:
 - Don't add pi0s in specific conditions → using vertex mass for MVA input
e.g.) no pi0s will come on D meson peak



- Making wrong mass shift effect smallest
 - Checking pi0s from large energy to small energy
 - Update vertex momentum when a pi0 candidate is found
→ add pi0 4-momentum to vertex momentum, and use it for next pi0 check

VERTEX FINDING

- Testing the vertex finding of π^0
- Thirdary vertices with $K^+ \pi$ tracks in b-jets
- π^0 candidates are $MVA_{output} > 0.83$ → needs optimization
- Unbelievable... D meson mass can be recovered well!!
- Works too good... Needs many check!



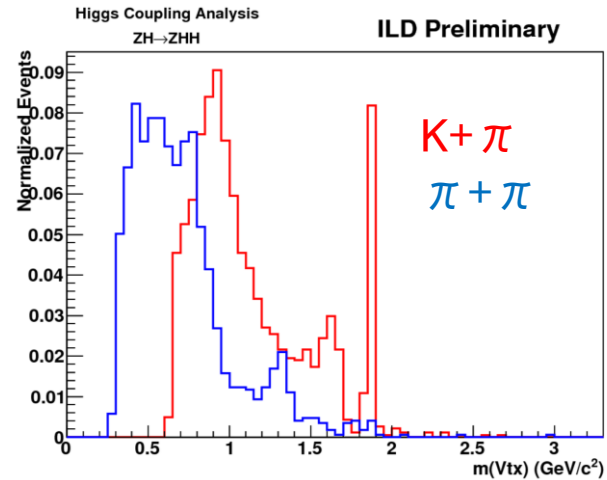
NEXT STEP

- There seems hope to attach π^0 s for vertex mass improvement
- But, the situation is very specific one
 - 2tracks($K + \pi$), tertiary vertices in b-jets
- Vertex mass should be the input variable of MVA
 - This variable will break the generality!
- If so, are classifiers necessary for all the vertex patterns?
 - That will be the best answer, but chaotic and hopeless!
- Can general and good classifier be constructed?

A CLUE

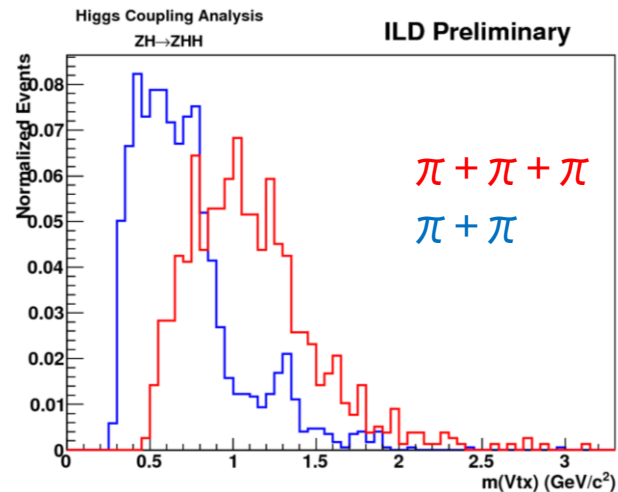
- Different vertex patterns have different **vertex mass patterns**
- e.g. 1) same num. of tracks with different particle patterns

- $K + \pi$ vs. $\pi + \pi$
- From thirday in bjet



- e.g. 2) different num. of tracks with same particle

- $\pi + \pi$ vs. $\pi + \pi + \pi$
- From thirday in bjet

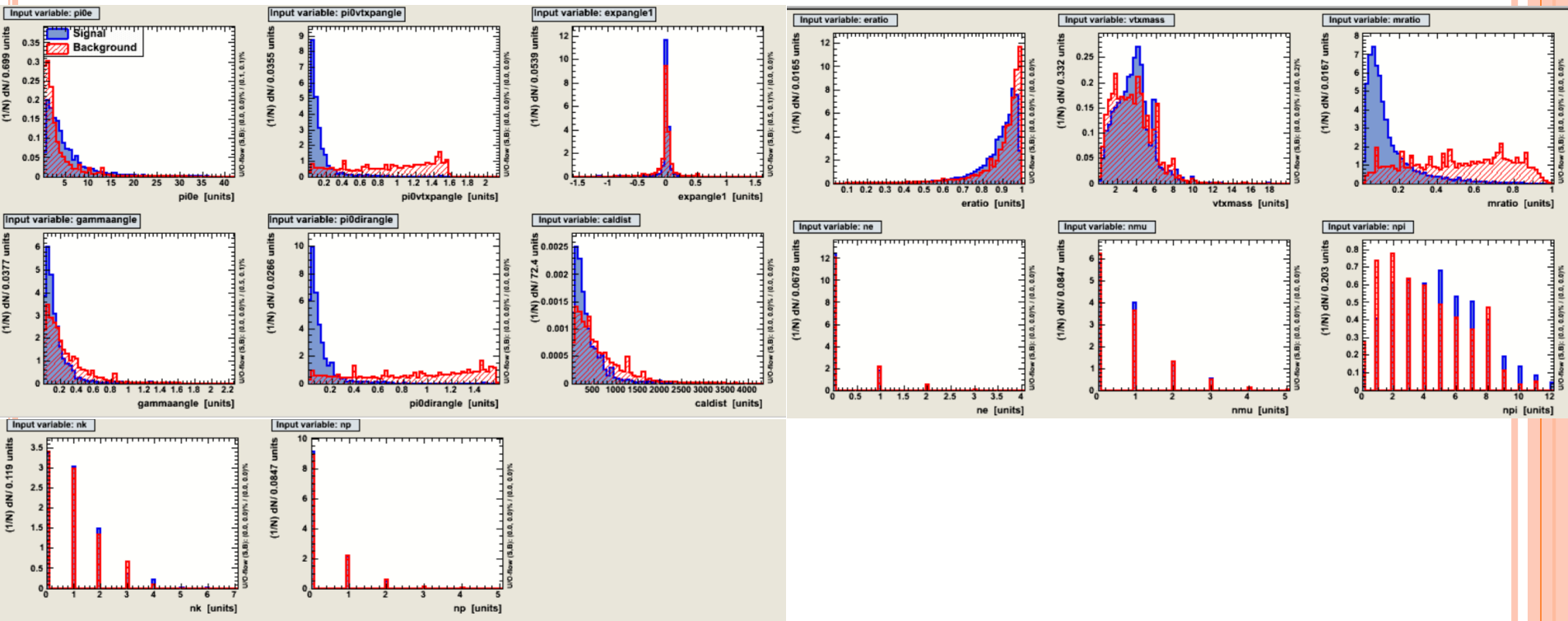


INPUT VARIABLES TO CONSTRUCT A GENERAL CLASSIFIER

- How is the result when num. of particles are used as input variables?
 - Num. of $e / \mu / \pi / K / p$ in the vertices – using particle ID
 - But, those variables are not variables for background rejection, but are variables for vertex classification
 - Do those variables work as variables for vertex classification in the MVA classifier?
- Num. of tracks in vertices **must not** be a variable
 - Don't need the bias from num. of tracks in vertices
 - weighting samples to erase such bias
- I have constructed the 3 types of MVA classifiers:
 - For thirday vertices
 - For secondary vertices which have thirday vertices
 - **For secondary vertices which don't have thirday**
 - Using b jets

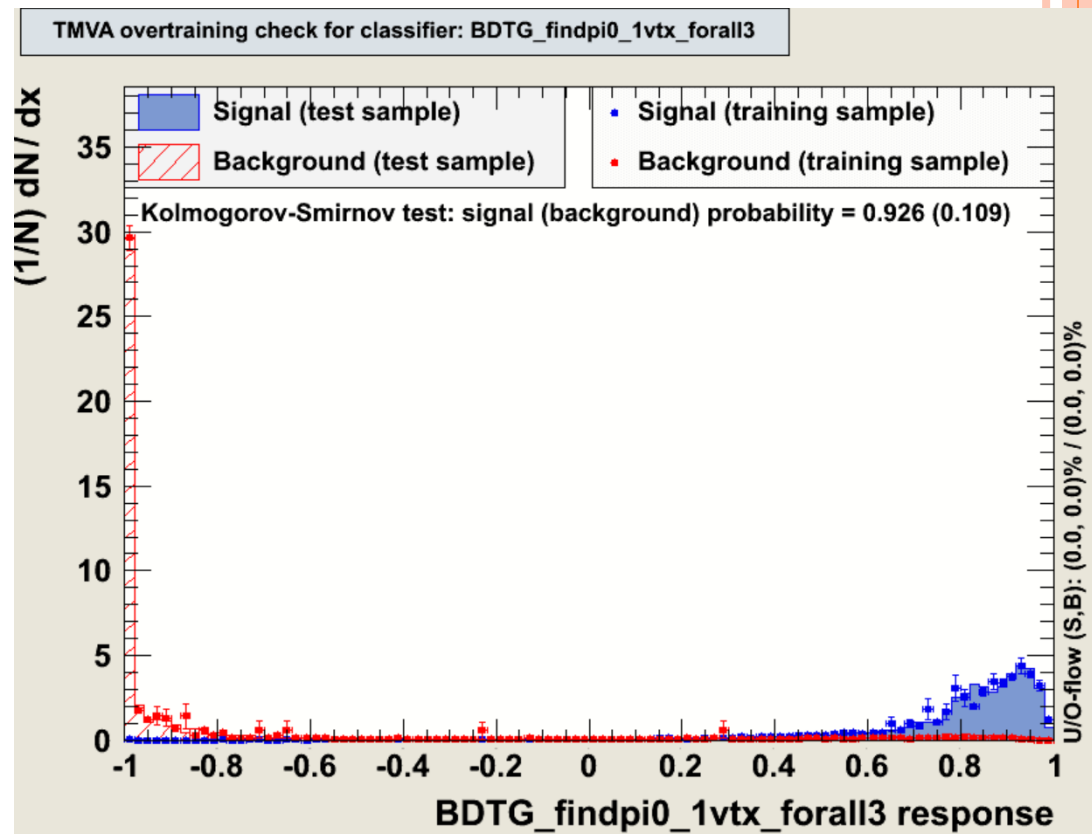
MVA – USING TMVA

- Input variables to be used
 - Secondary vertices which don't have thirdary



MVA OUTPUT

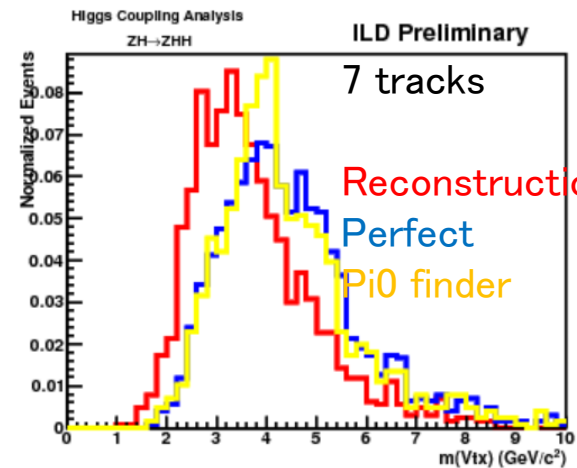
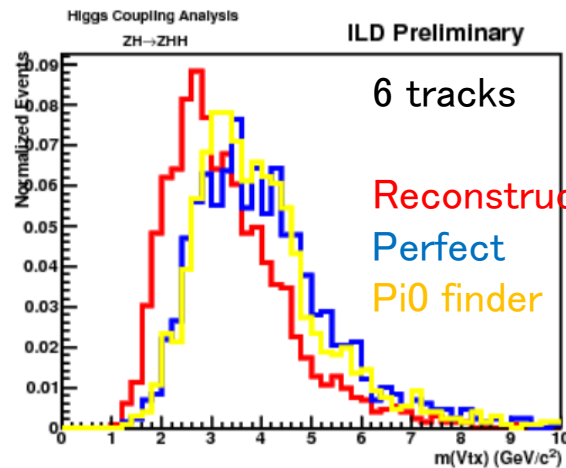
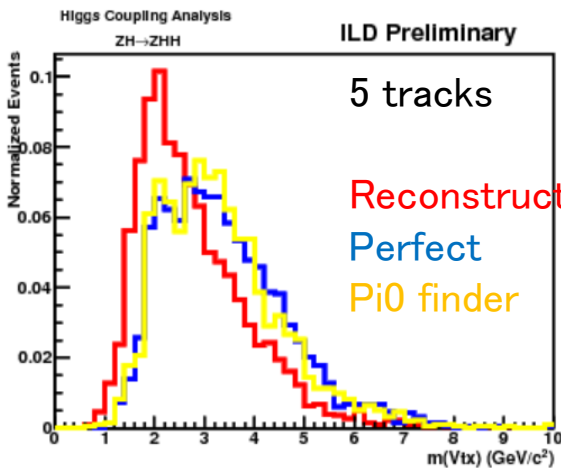
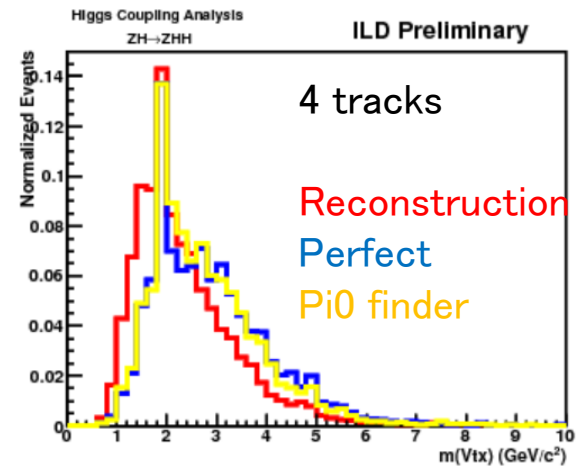
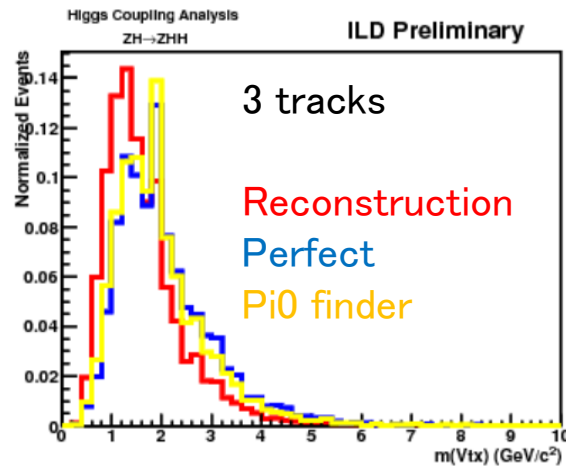
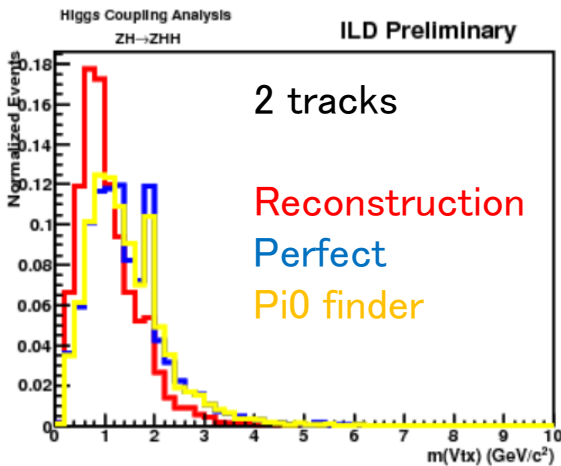
- Signal: pi0s from secondary vertices which don't have thirday
- Background: pi0s from primary($L_{\text{decay}} < 0.3\text{mm}$)
- All the pi0s are assumed to come from secondary vertex
 - Correct gammas & pi0 momentum
- Using Gradient BDT
- MVAcut > 0.79 ($n_{\text{trk}} \geq 3$)
 > 0.69 ($n_{\text{trk}} = 2$)



Vtx Masses

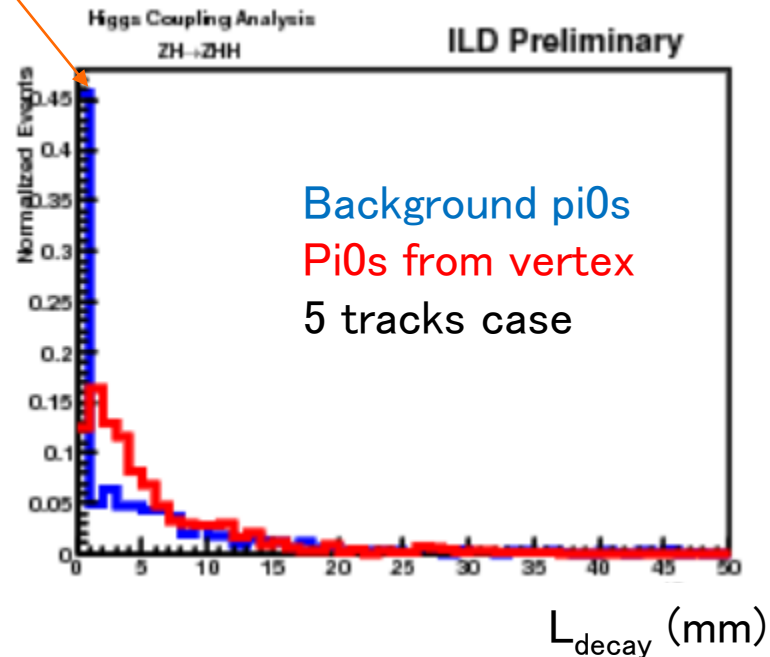
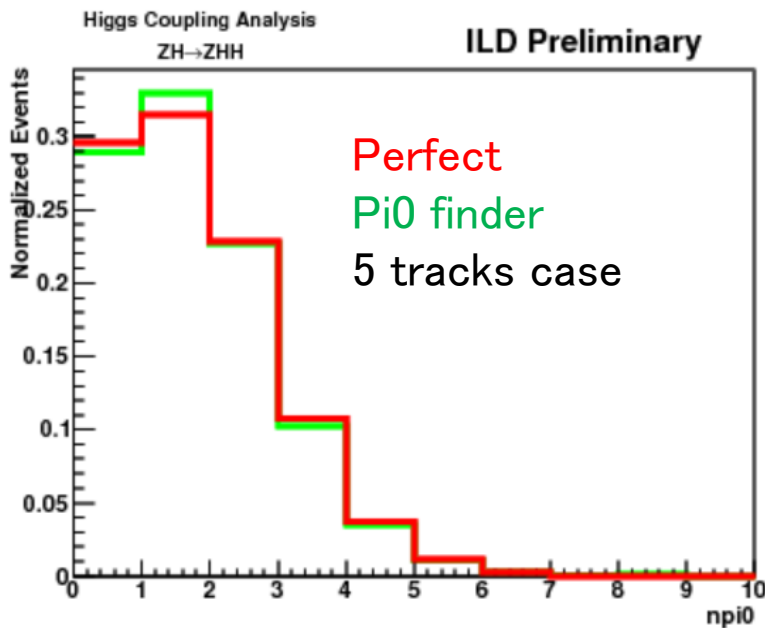
- Vtx mass distributions for each vertex pattern (ntrk)

- not so bad
- 2track case has bias...



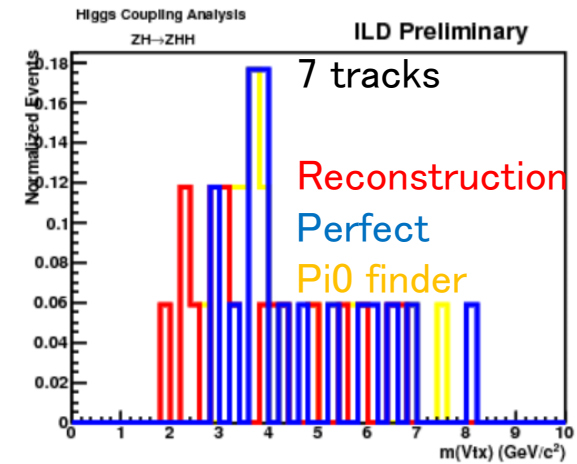
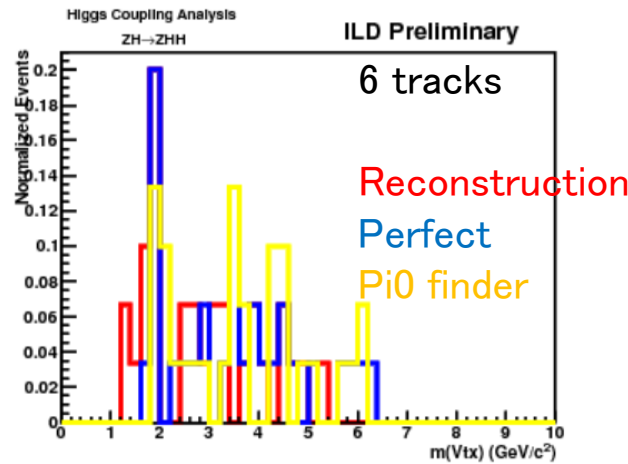
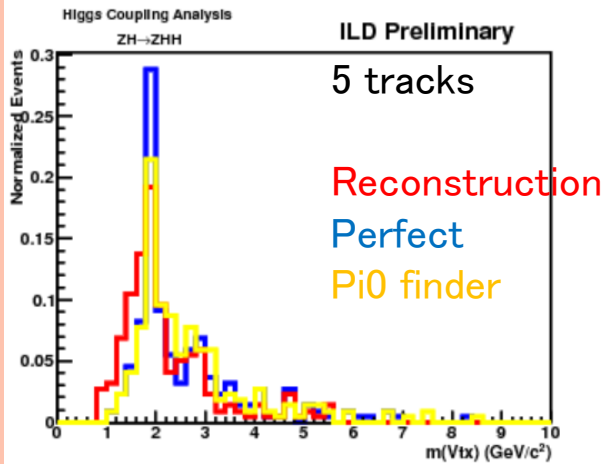
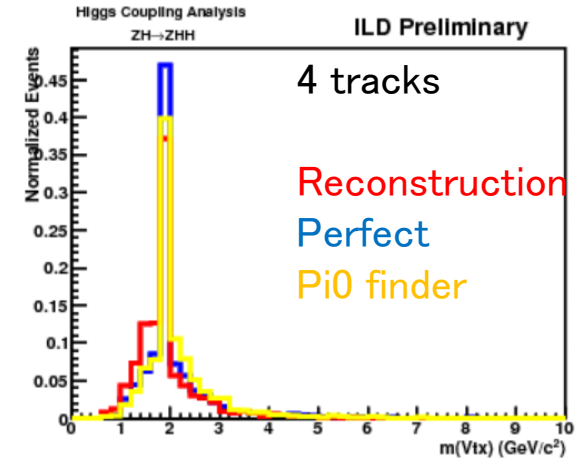
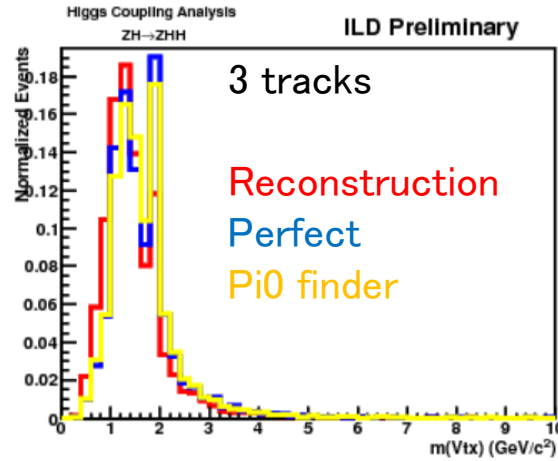
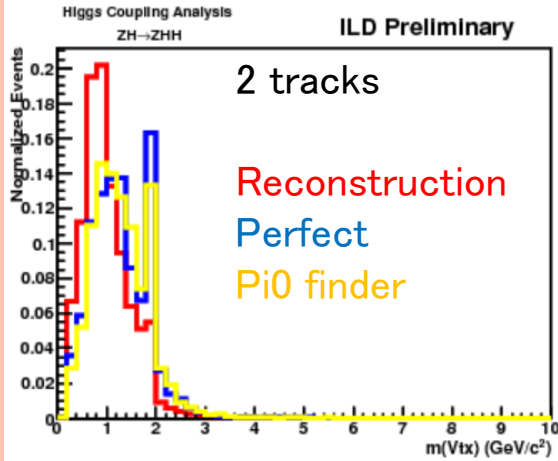
SOME PLOTS

- Num. of pi0s to be attached → determine MVAcut by it
- Where do pi0s really come from?
 - Many pi0s from primary are mis-attached to the vertices
 - Now, that is limited by detector configuration (can't determine exact gamma direction)
 - To some extent, an idea to catch gamma direction is necessary



TESTING FOR SOME TOPICS

- Attaching pi0s to c vertex using same classifier
 - So far, no strange behavior

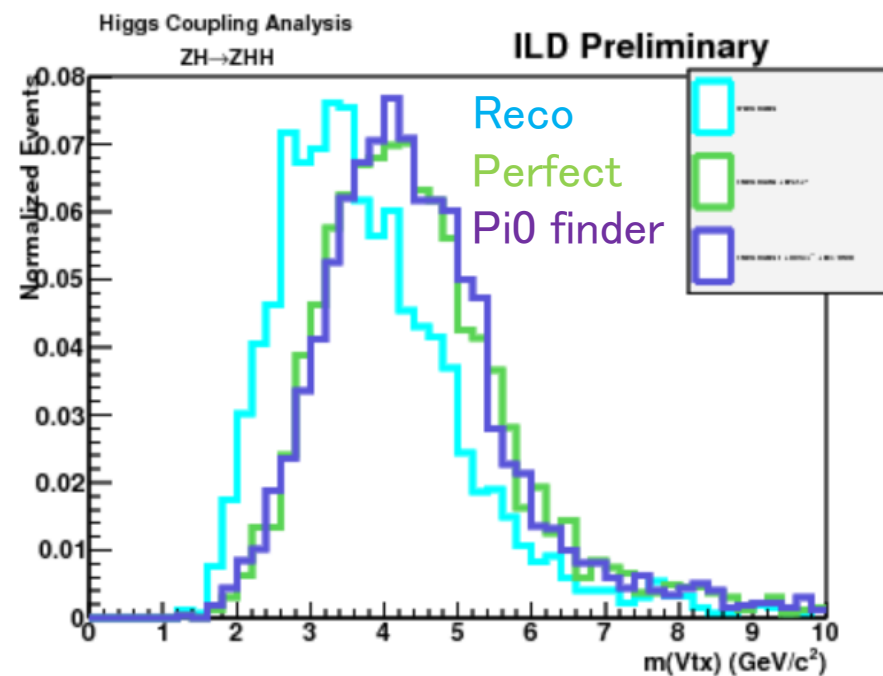
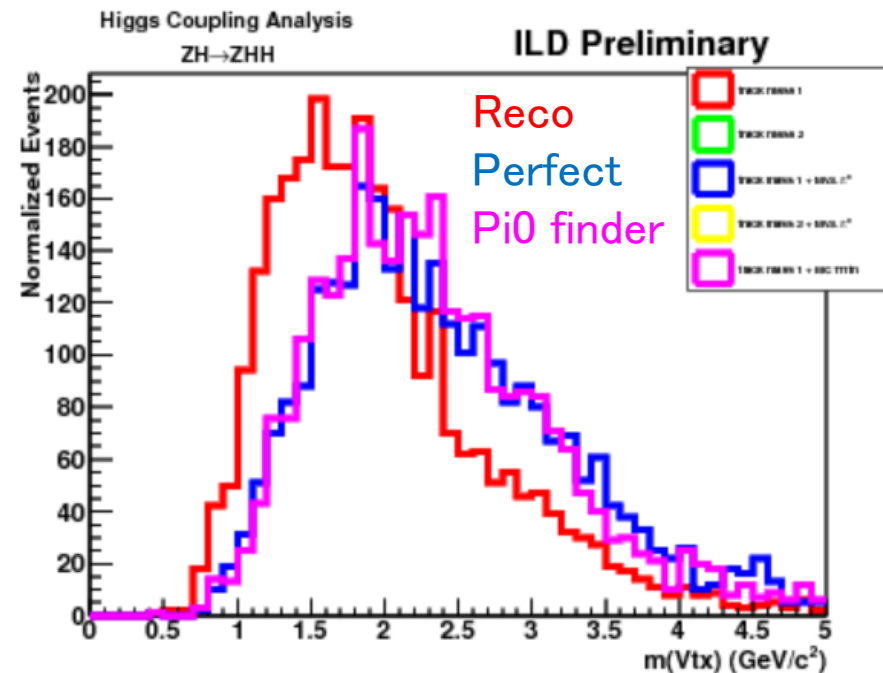


- Now, trying to check ljet case...

GLANCE AT OTHER CASE

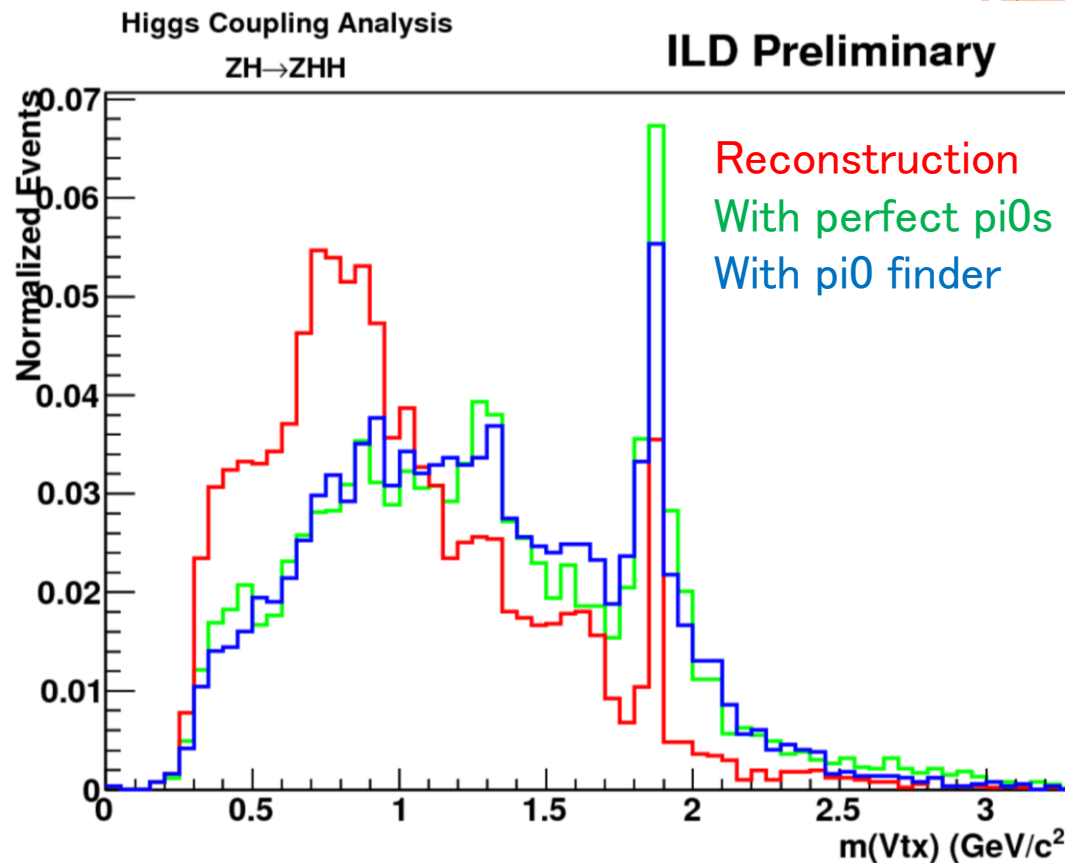
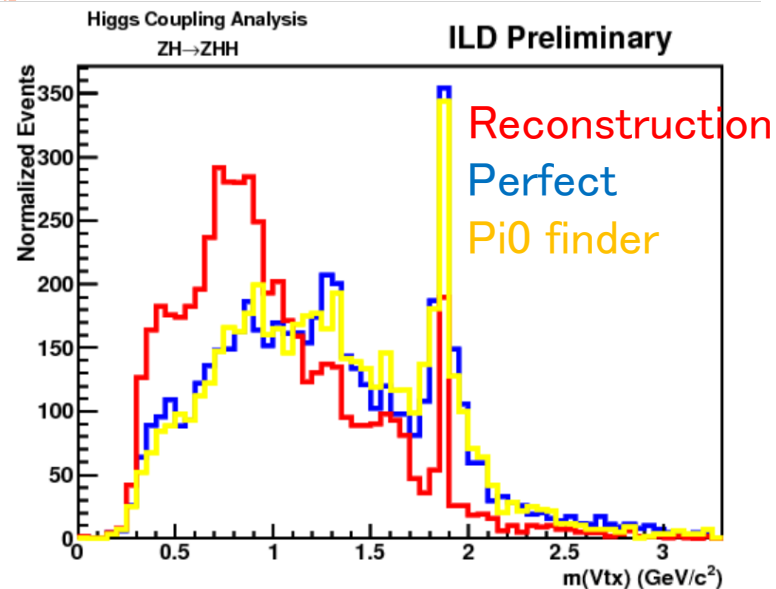
- 2 vertices in bjet
 - Secondary vertex – 4tracks case

- Merging with thirdary vertex
 - Thirdary vertices allow all the patterns



CHECK IN MORE REALISTIC SITUATION

- Using gamma finder & pi0 finder
 - Looking for gamma pair & constructing pi0 candidates
 - Using those pi0s, try to attach them to the vertices
 - Not yet contaminate neutral hadrons
 - 2tracks, thirdary vertices in bjet
 - Optimization is necessary



PROBLEMS AND TODO

- There seems hope for attaching π^0 s to vertices
 - Vertex mass recovery is reasonable
 - Of course, many checks are necessary
 - More optimization is necessary
- Mis-attaching of π^0 s are not so negligible
 - That is limited by detector configuration
 - To some extent, determination of exact gamma direction is necessary
- Problems & Todo
 - π^0 reconstruction eff. is so bad \rightarrow so far, $\sim 50\%$
 - Erase bias of vertex patterns
 - Contamination of neutral hadrons \rightarrow test in the most realistic situation
 - Compare bjet/cjet/ljet case precisely
- Finally, check the flavor tagging effs.!



QUICK STUDY FOR FLAVOR TAGGER IMPROVEMENT IN THE CASE OF 0VTX

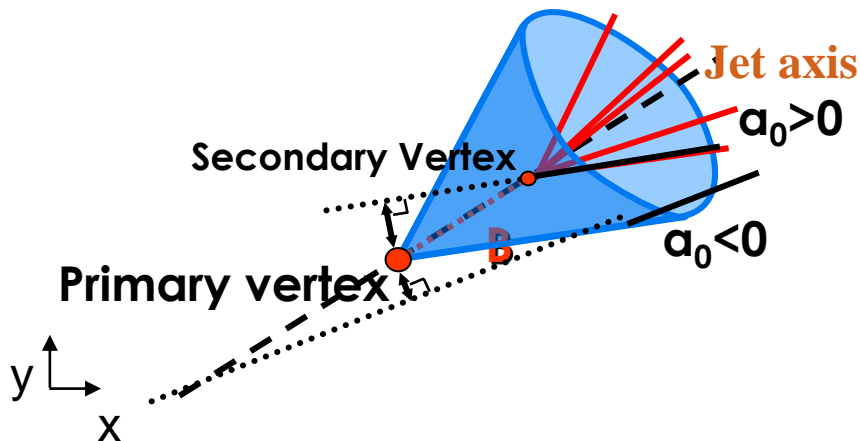
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INTRODUCTION

- Most difficult situation for discriminating light/heavy jet is the case when there is **no secondary vertex** in the jet!
- In this case, only impact parameter is the variable which implies the existence of secondary vertex for flavor tagging
- Is there room to improve efficiency in such situation?
 - **Especially, using particle ID!**
- I'm looking at several variables in such case...
 - Can I get a clue for the improvement?
 - I'll show some points
 - needs help and comments for future study

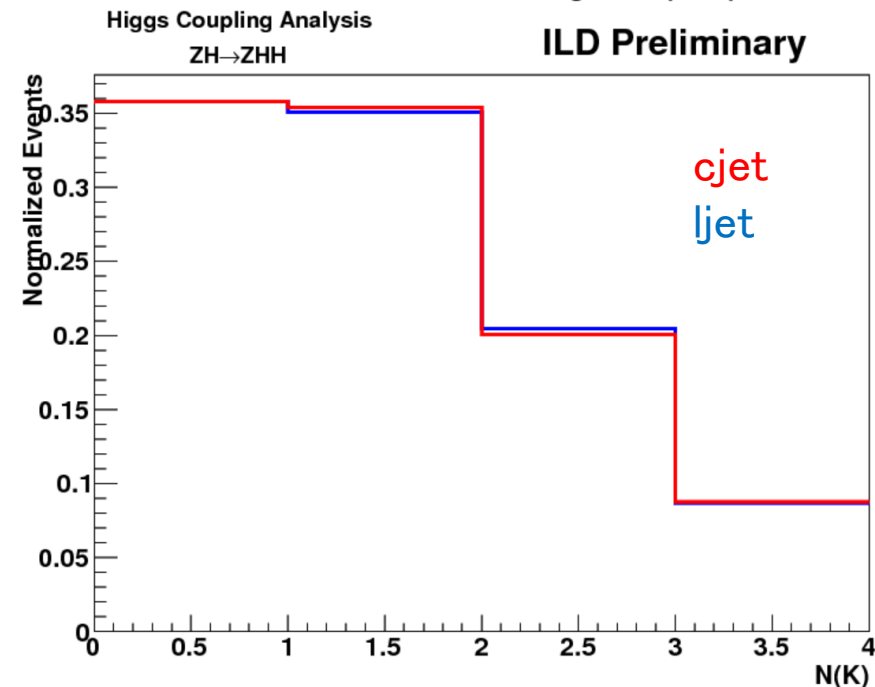
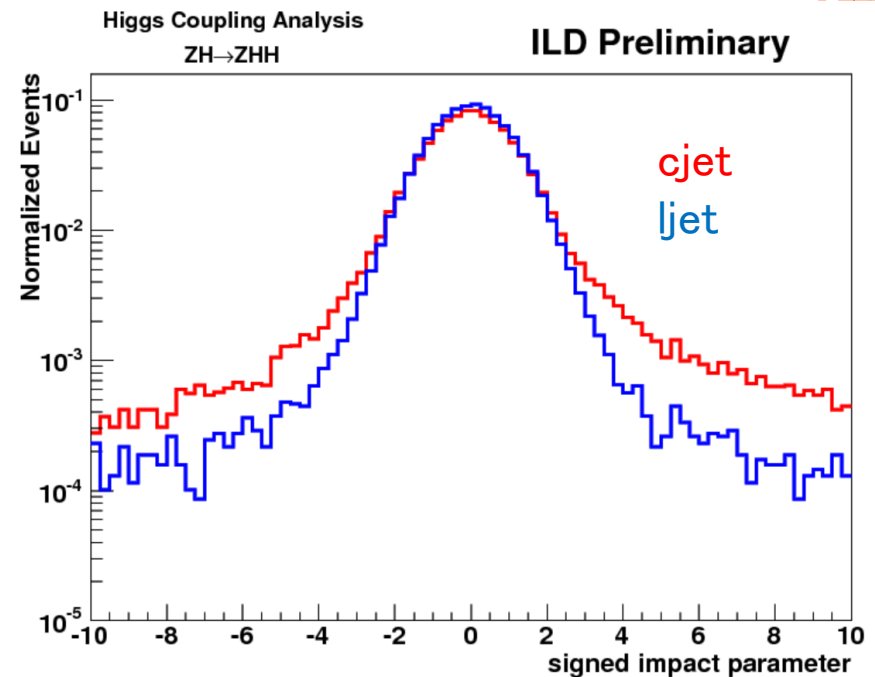
SIGNED IMPACT PARAMETER

○ cjet v.s. ljet



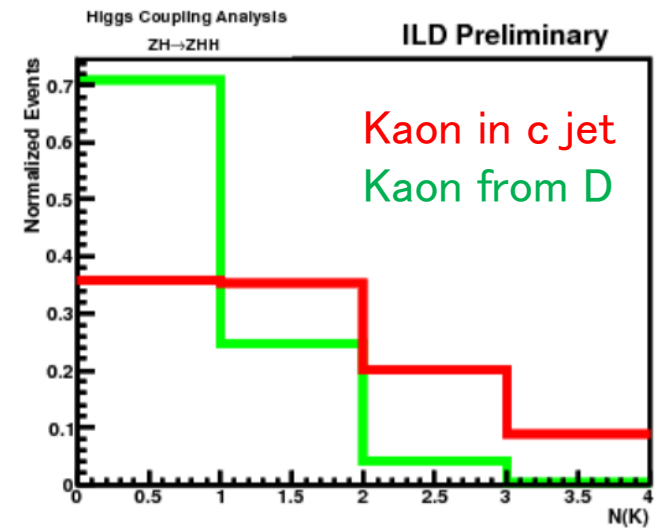
○ Num. of Kaon candidates in the jet

- Using particle ID
- >65% jets have Kaon candidates
- Looks no difference between c/l jet

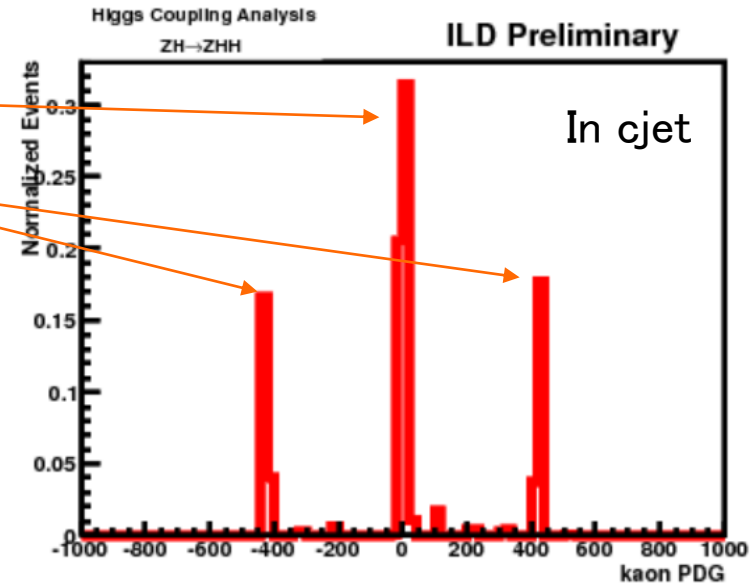


QUICK STUDY

- Kaon from D meson & c baryon
 - $\sim 30\%$ jets – Kaons are daughters of D meson & c baryon



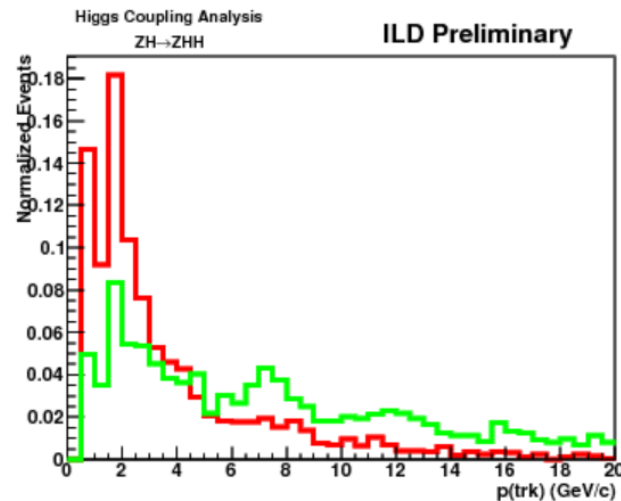
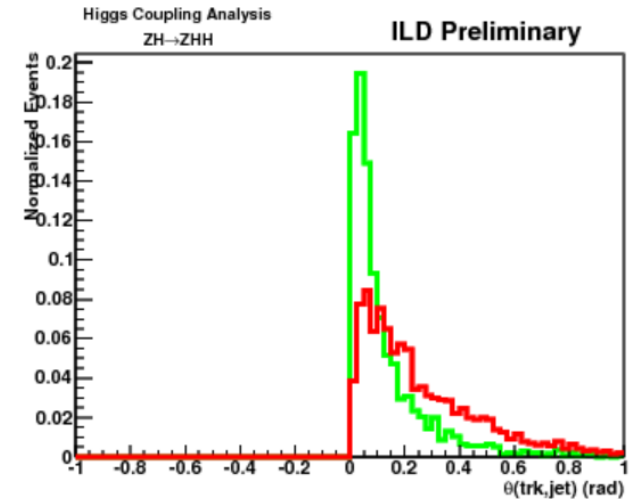
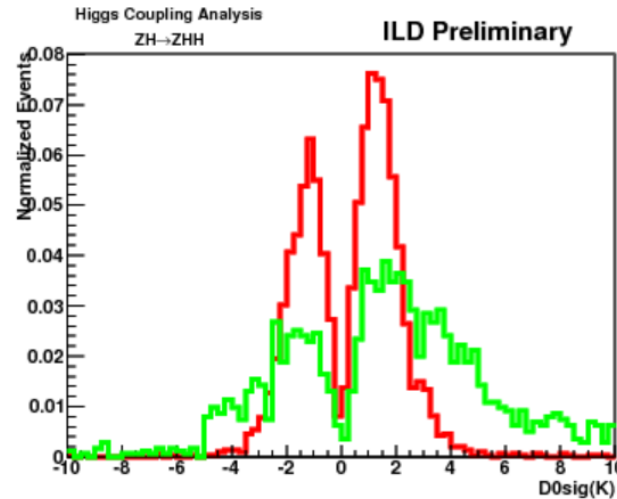
- Focus on Kaon with largest signed impact parameter
 - Kaon is tagged using particle ID
- Where does Kaon come from? → check mother
 - Intermediate resonance skipped
 - $\sim 70\%$ Kaons are from primary
 - $\sim 30\%$ Kaons are from D meson
 - A few from c baryon
- Can Kaons from D meson tagged well?



MORE

Looking at more plots

- Kaons from D meson are:
 - Larger impact parameter
 - More collinear to jet axis
 - More energetic



Kaon from primary
Kaon from D meson