



# STUDY OF THE POSSIBILITY OF ATTACHING PI0S TO VERTICES(INCLUDING PARTICLEID)

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Analysis&Software meeting

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## INTRODUCTION

### ○ For flavor tagging improvement

- Vertex mass is the key to separate heavy/light flavor vertex
- Many  $\pi^0$ 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  $\pi^0$ s which escape from vertices?

### ○ We are studying the possibility of vertex mass recovery using $\pi^0$ s

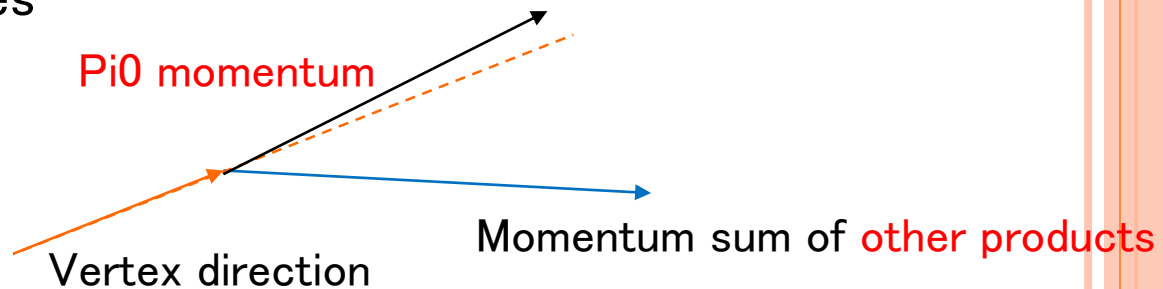
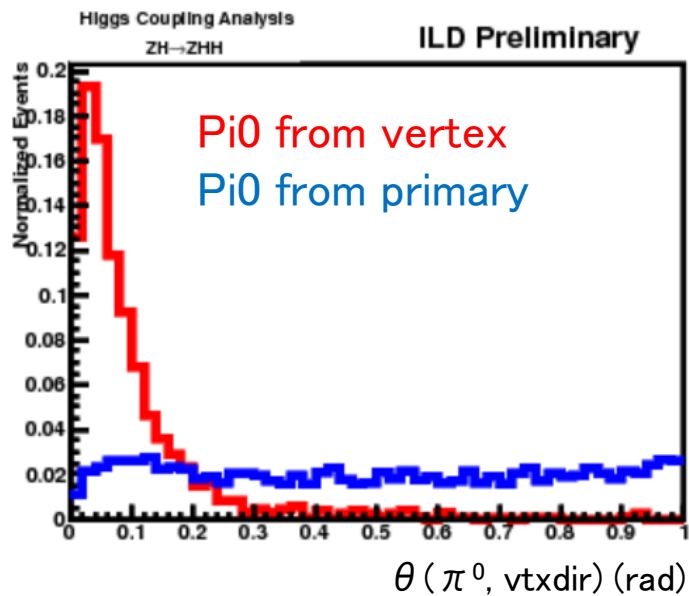
- Vertex finder – which vertex is the  $\pi^0$  coming?
- In this talk,  $\pi^0$  gamma pairing is perfect within gamma reconstruction capacity

### ○ Finding vertex of $\pi^0$ s

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

# KEY ISSUES

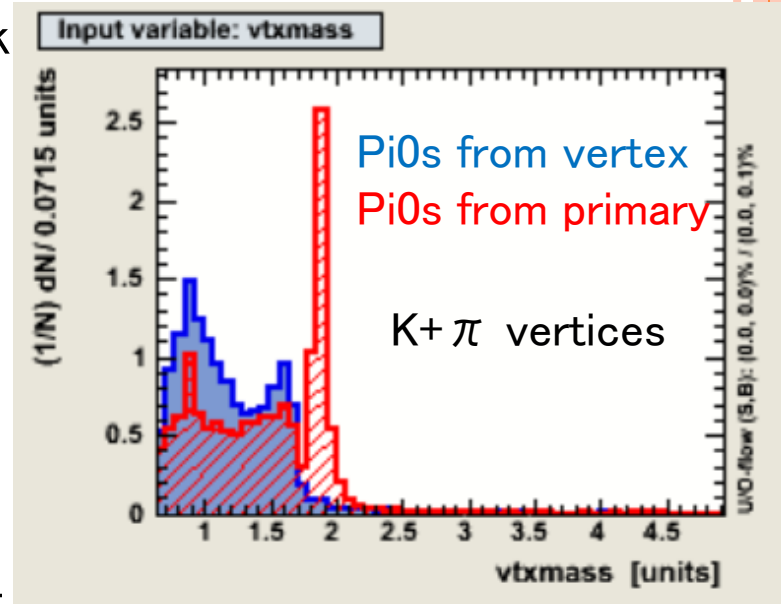
- Pi0s from (secondary, third) vertices are very collinear to vertex direction
  - due to their small masses



- 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

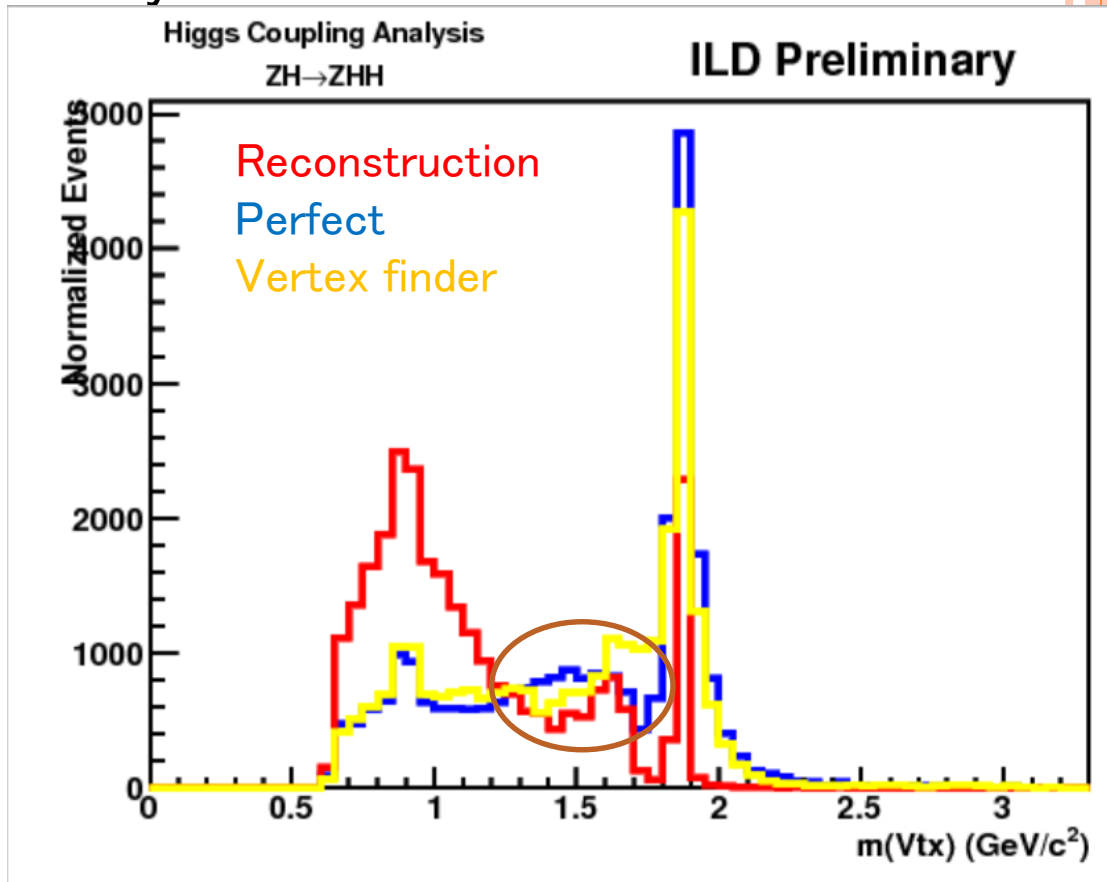
- To avoid attaching too many pi0s:
  - Don't add pi0s in specific conditions → using vertex mass for MVA input  
e.g.) no pi0s will come on D meson peak



- Making wrong mass shift effect smallest
  - Checking pi0s from large energy to small energy
    - Arrange pi0s in descending order of those energies
  - 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  $\pi^0$
- Third vertices with  $K^+ \pi^-$  tracks in b-jets (corresponds to D vtx?)
- $\pi^0$  candidates are  $MVA_{\text{output}} > 0.83 \rightarrow$  needs optimization
- Unbelievable... D meson mass can be recovered well!!
- Works too good... Needs many check!



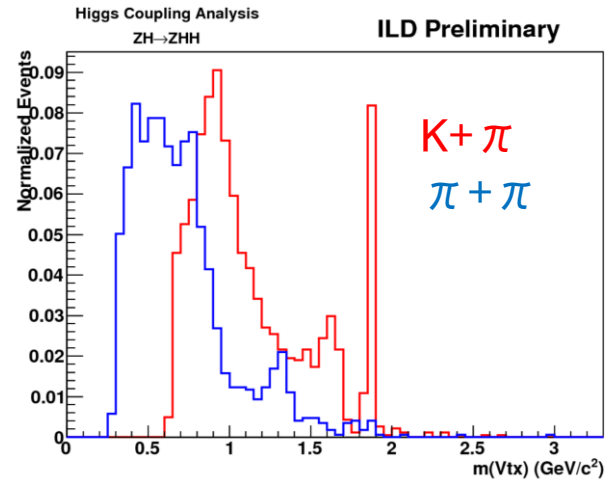
## NEXT STEP

- There seems hope to attach  $\pi^0$ s for vertex mass improvement
- But, the situation is very specific one
  - 2tracks( $K + \pi$ ), third 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

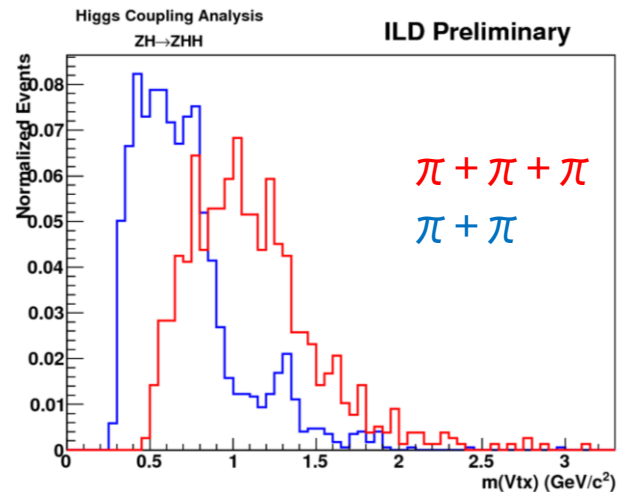
- Different vertex patterns have different **vertex mass patterns**
- e.g. 1) same num. of tracks with different particle patterns

- $K + \pi$  vs.  $\pi + \pi$
- From third vertex in bjet



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

- $\pi + \pi$  vs.  $\pi + \pi + \pi$
- From third vertex in bjet



# INPUT VARIABLES TO CONSTRUCT A GENERAL CLASSIFIER

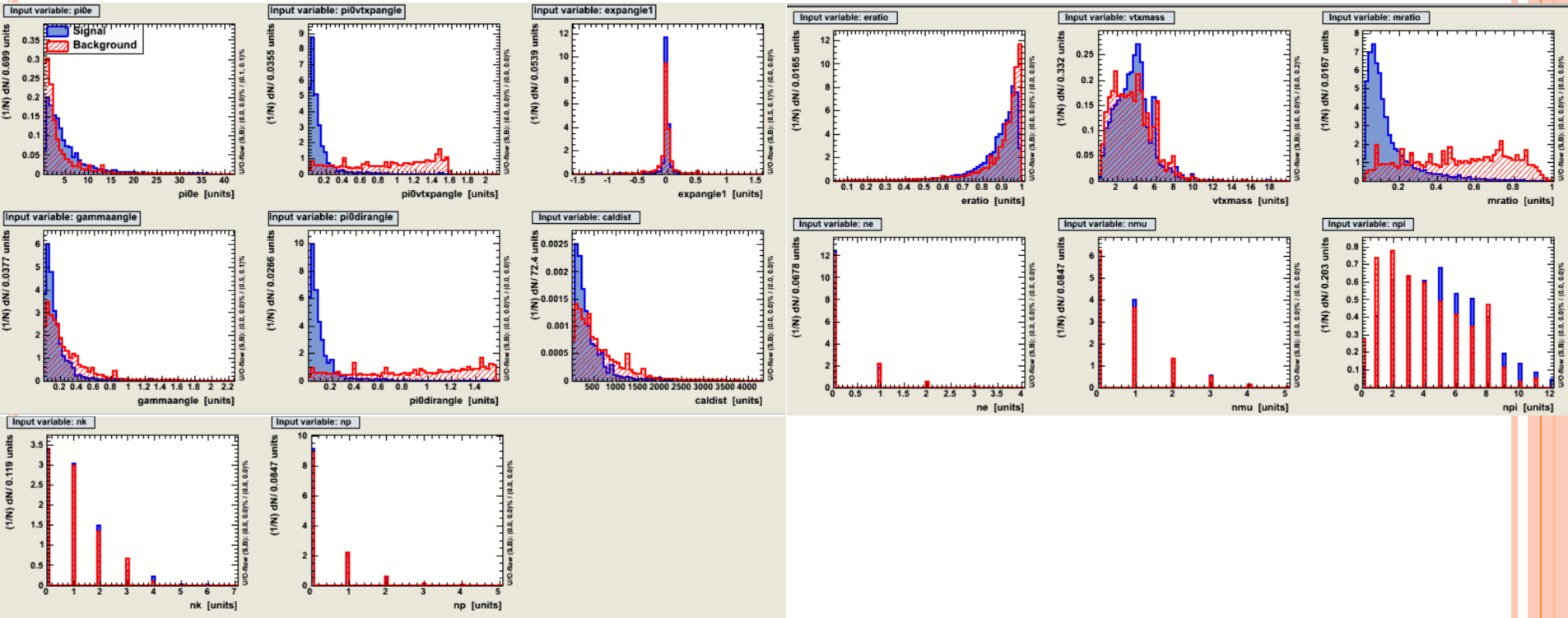
- How is the result when num. of particles are used as input variables?
  - Num. of  $e/\mu/\pi/K/p$  in the vertices – **using particle ID**
  - But, those variables are not variables for background rejection, but are variables for vertex classification
  - Do those variables work as variables for vertex 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 third vertices
  - For secondary vertices which have third vertices
  - **For secondary vertices which don't have third vertex**
  - Using b jets



# MVA – USING TMVA

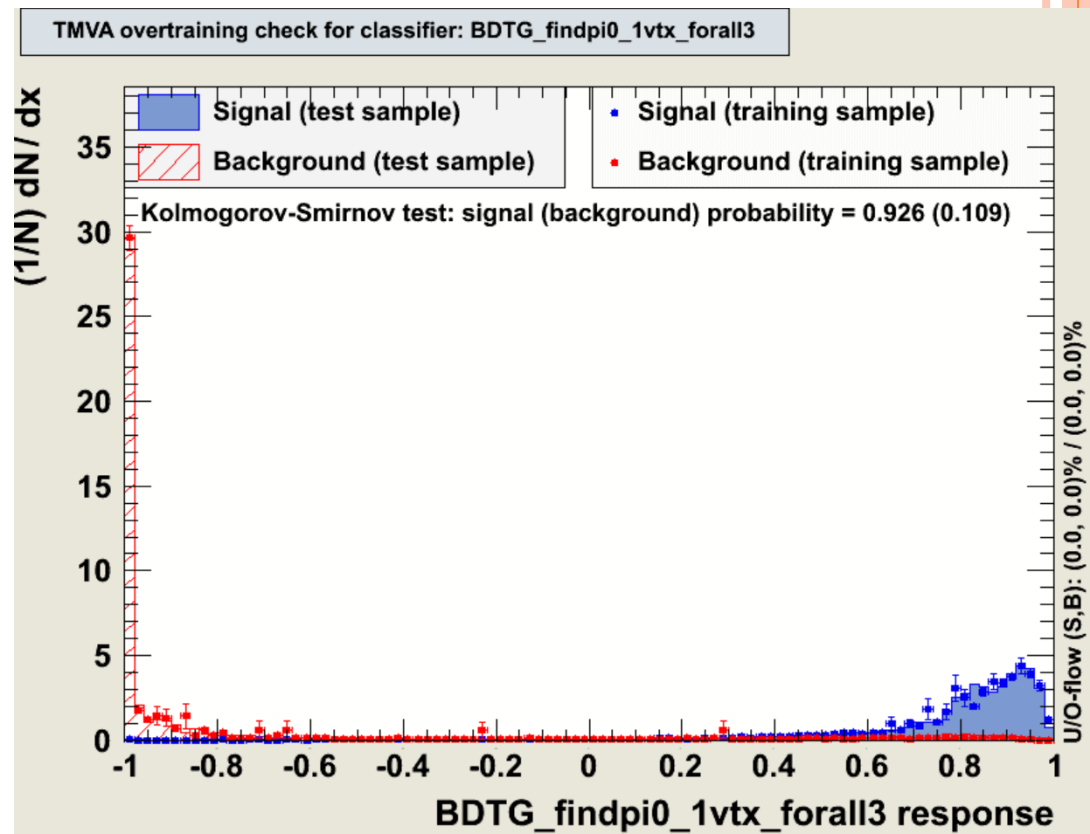
## Input variables to be used

- Secondary vertices which don't have third vertex



# MVA OUTPUT

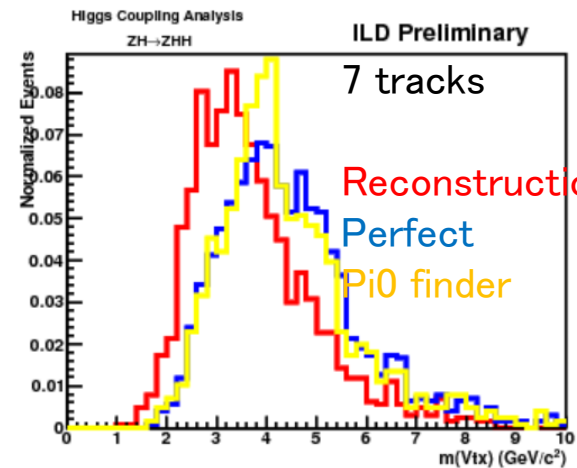
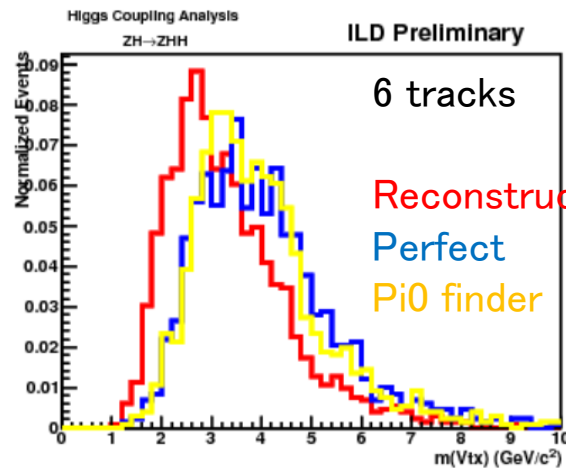
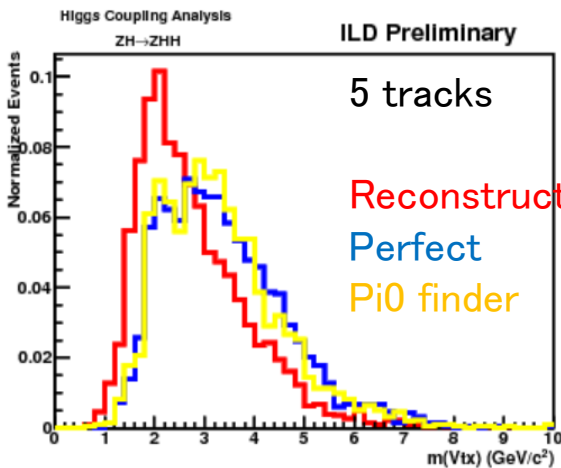
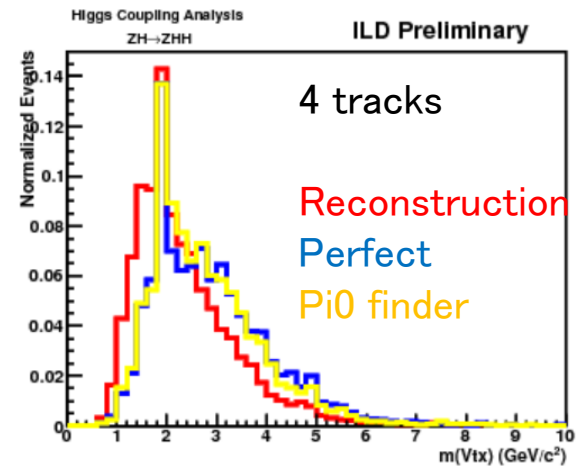
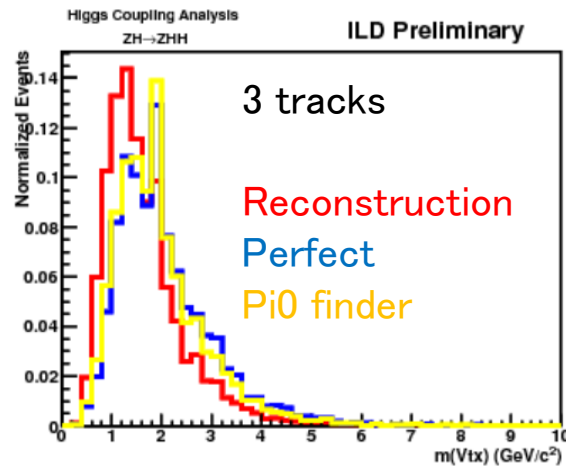
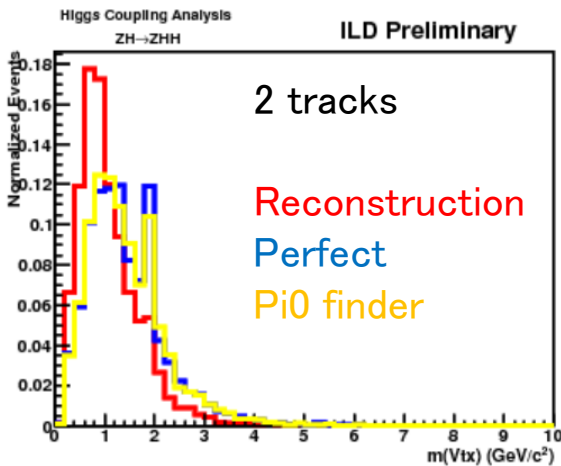
- Signal: pi0s from secondary vertices which don't have third vertex
- Background: pi0s from primary ( $L_{\text{decay}}$  from IP  $< 0.3\text{mm}$ )
- All the pi0s are assumed to come from secondary vertex
  - Correct gammas & pi0 momentum
- Using Gradient BDT
- MVAcut  $> 0.79$  ( $n_{\text{trk}}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



# Vtx Masses

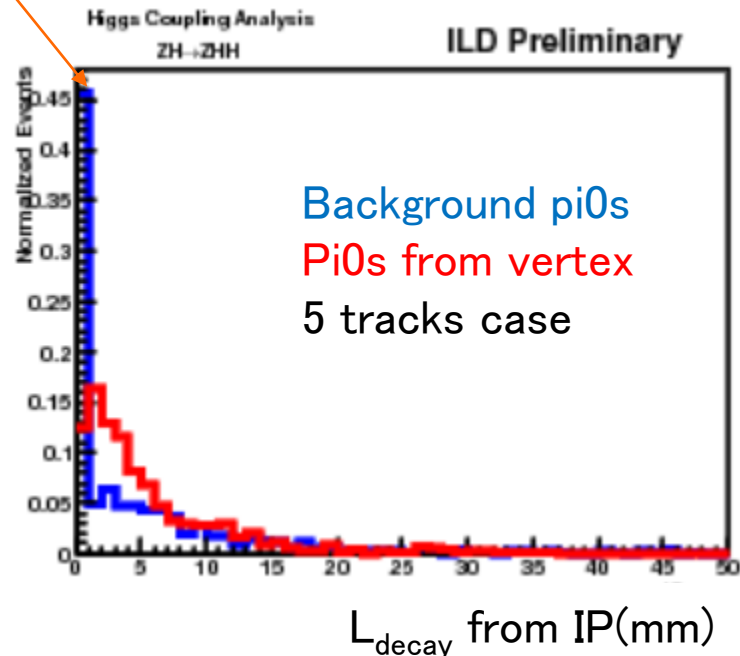
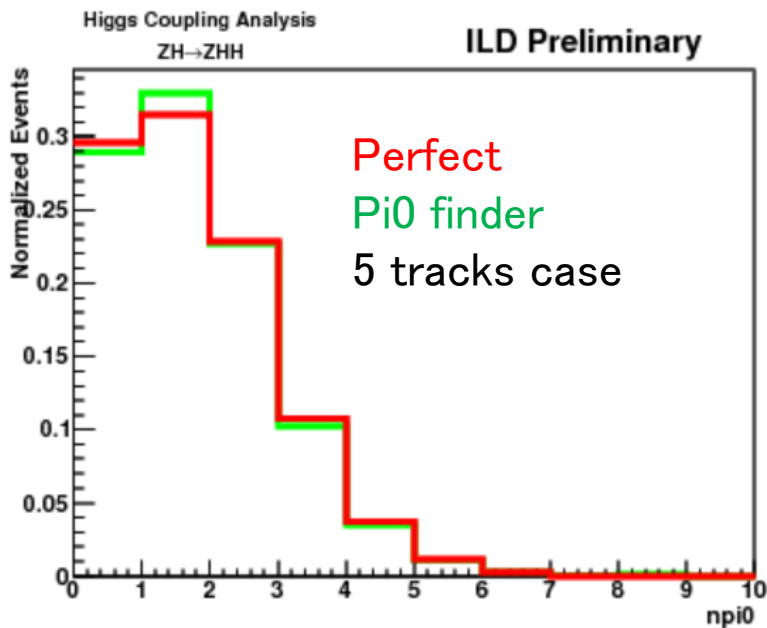
- Vtx mass distributions for each vertex pattern (ntrk)

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



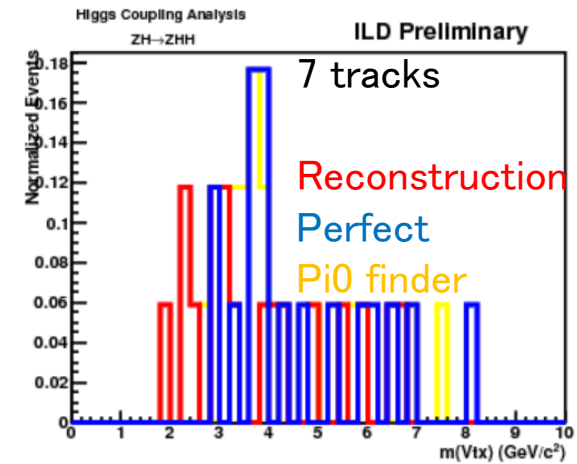
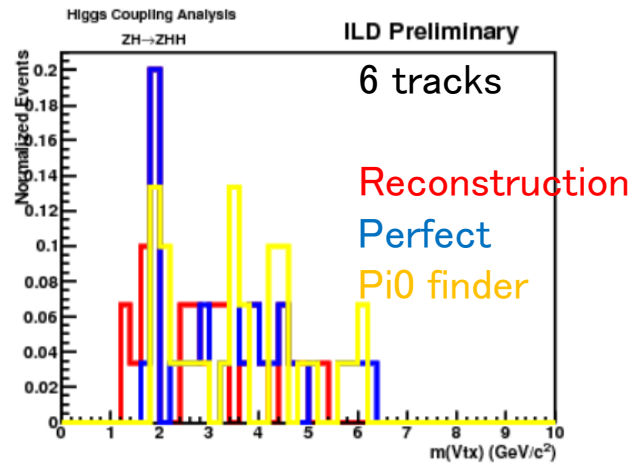
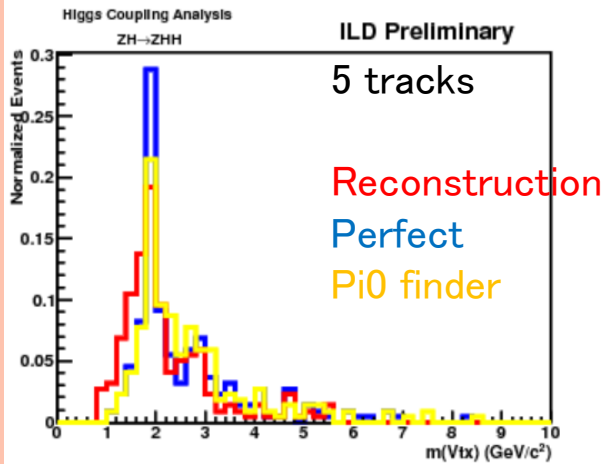
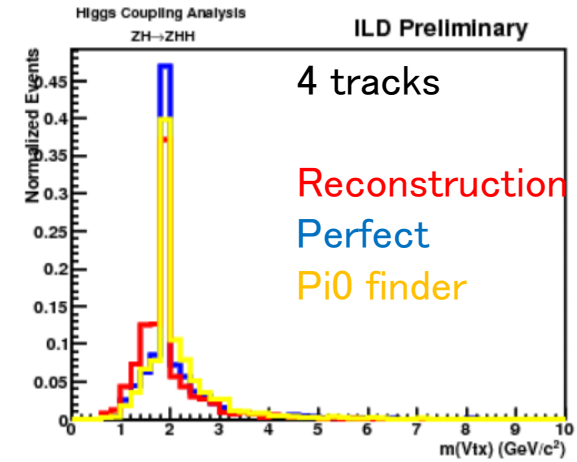
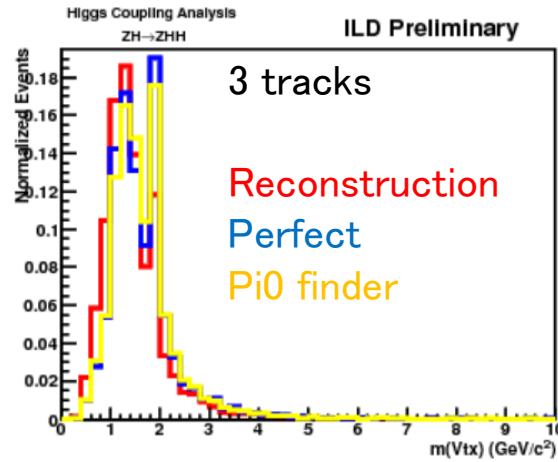
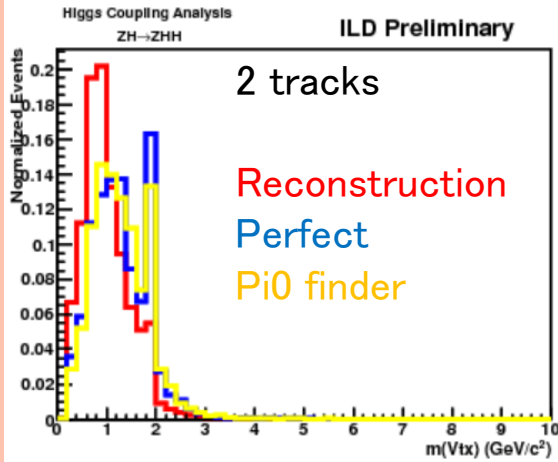
# SOME PLOTS

- 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

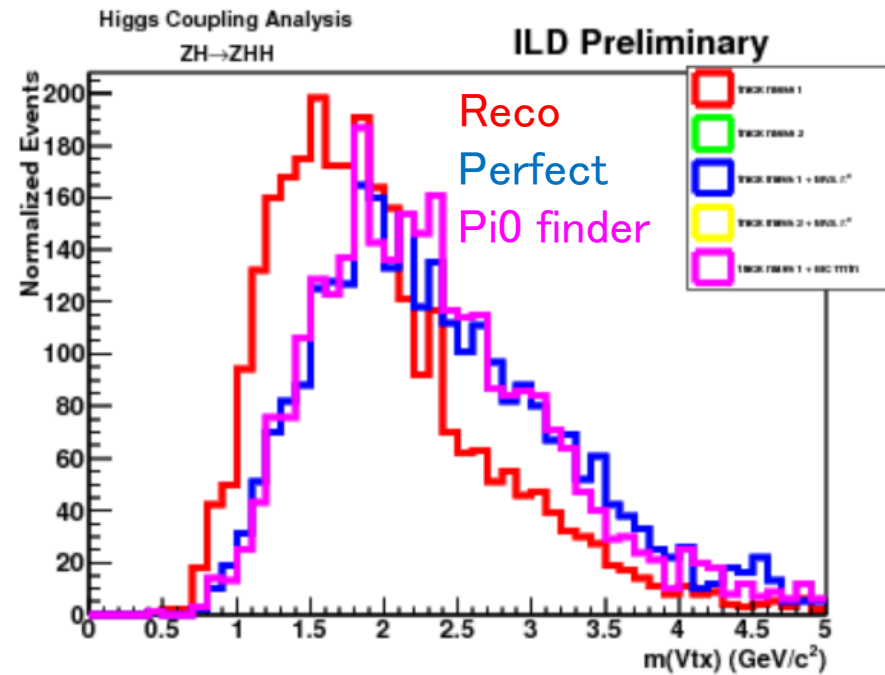
- Attaching pi0s to c vertex using same classifier
  - So far, no strange behavior



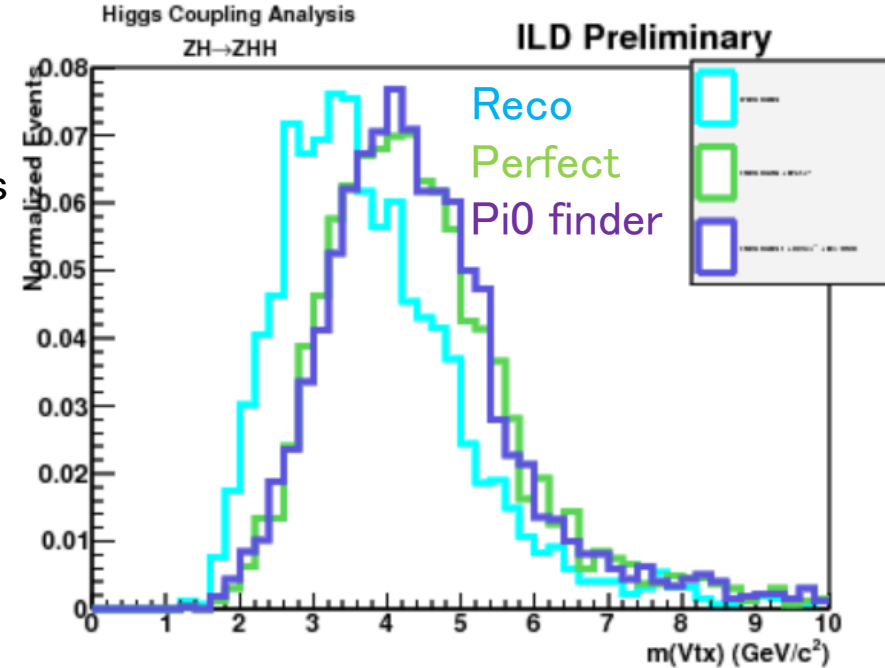
- Now, trying to check ljet case...

# GLANCE AT OTHER CASE

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



- Merging with third vertex
  - Third vertices allow all the track patterns



# SUMMARY, PROBLEMS AND PROSPECTS

- There seems hope for attaching  $\pi^0$ s to vertices
  - Vertex mass recovery is reasonable
  - Of course, many checks are necessary
  - More optimization is necessary
- Mis-attaching of  $\pi^0$ s are not so negligible
  - That is limited by detector configuration
  - To some extent, determination of exact gamma direction is necessary
- Prospects
  - **How is a realistic case?**
    - Gamma finder  $\rightarrow$   $\pi^0$  reconstruction  $\rightarrow$   $\pi^0$  vertex finder
    - Can vertex mass recovery be kept good?
- @LCWS14: focus on  $\pi^0$  reconstruction & vertex mass recovery in the most realistic case
- **Finally, check the flavor tagging effs.!**