



STUDY OF ATTACHING π^0 S TO VERTICES USING PARTICLE ID FOR FLAVOR TAGGING IMPROVEMENT

Masakazu Kurata
The University of Tokyo

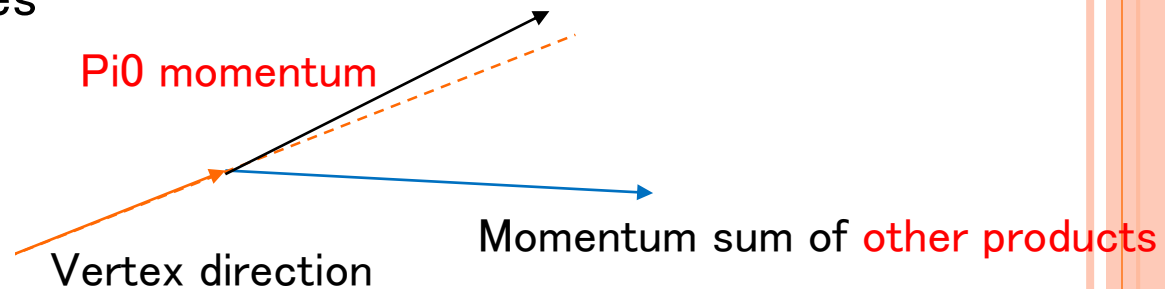
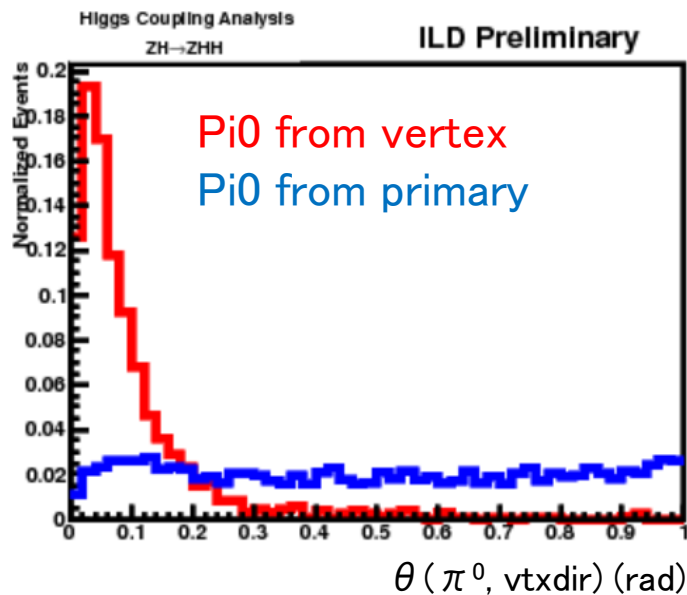
LCWS14, 10/06/2014–10/10/2014

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 → 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?
- We are studying the possibility of vertex mass recovery using π^0 s
 - Vertex finder – which vertex is the π^0 coming?
- Finding 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)
- How is in the realistic case? – need π^0 reconstruction
- Goal: flavor tagging efficiency improvement!

KEY ISSUES

- π^0 s from (secondary, third) vertices are very collinear to vertex direction
 - due to their small masses

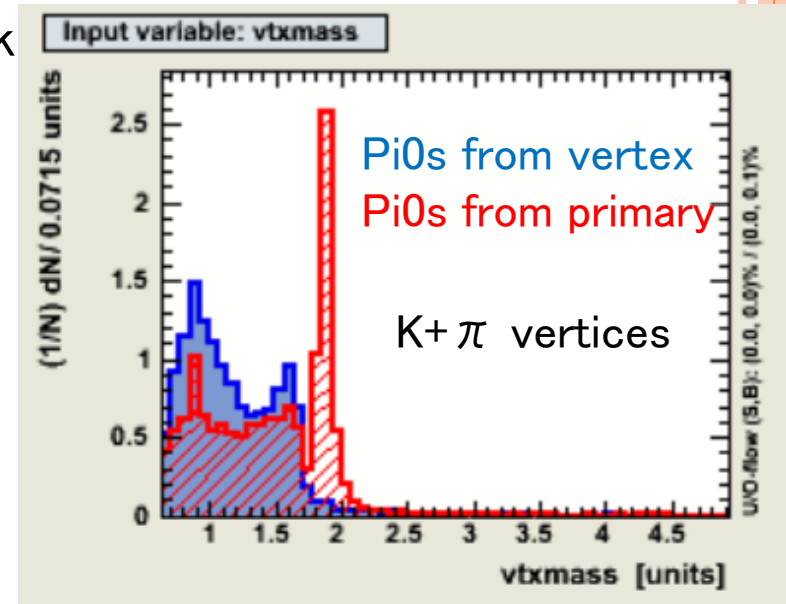


- But, there are many π^0 s which come from primary vertex & are accidentally collinear to the vertex direction!
 - Ref.) In qqHH events, 50 \sim 60 π^0 s will be produced!!

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

- **Generality can't keep out to this variable!**



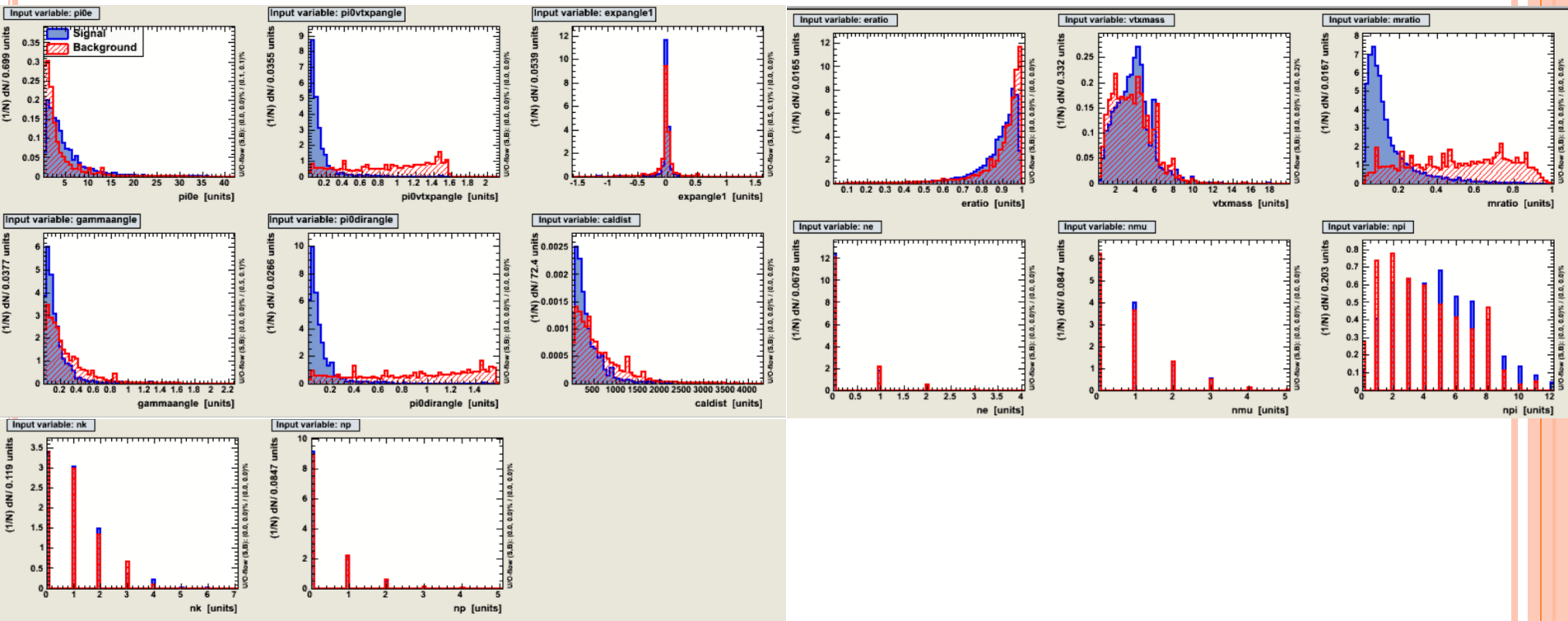
- Making wrong mass shift effect smallest
 - Checking pi0s from large energy to small energy
 - Arrange pi0s in descending order of those energies
 - Update vertex momentum when a pi0 candidate is found
 - add pi0 4-momentum to vertex momentum, and use it for next pi0 check

INPUT VARIABLES TO CONSTRUCT A GENERAL CLASSIFIER

- Getting general – num. of particles are used as input variables
 - Num. of $e/\mu/\pi/K/p$ in the vertices – **using particle ID**
 - 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

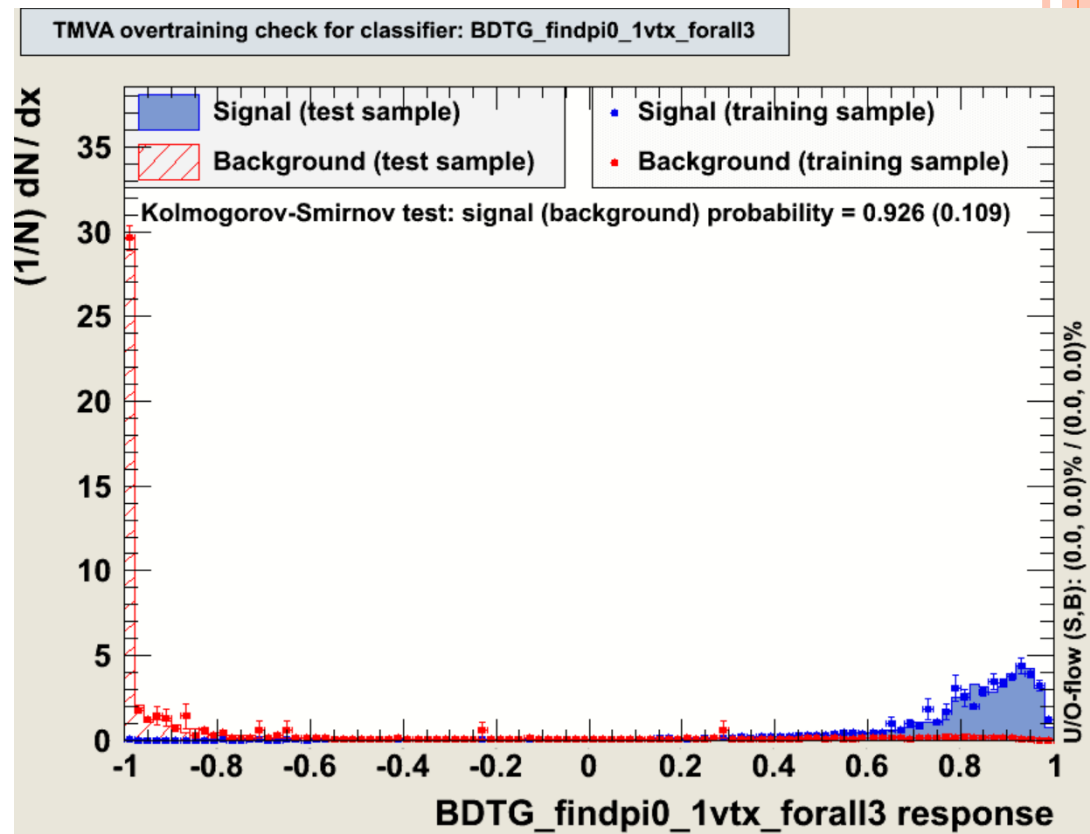
MVA – USING TMVA

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



MVA OUTPUT

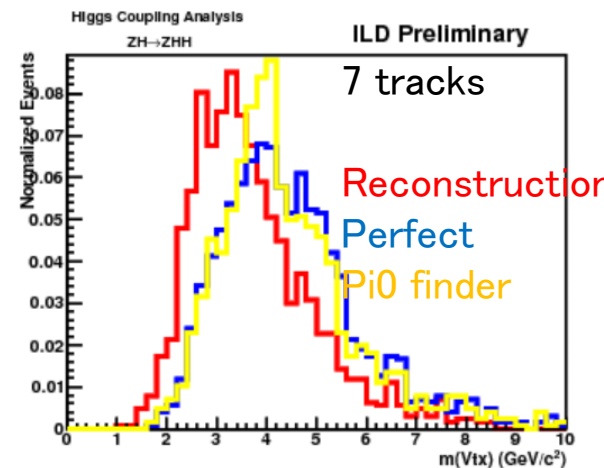
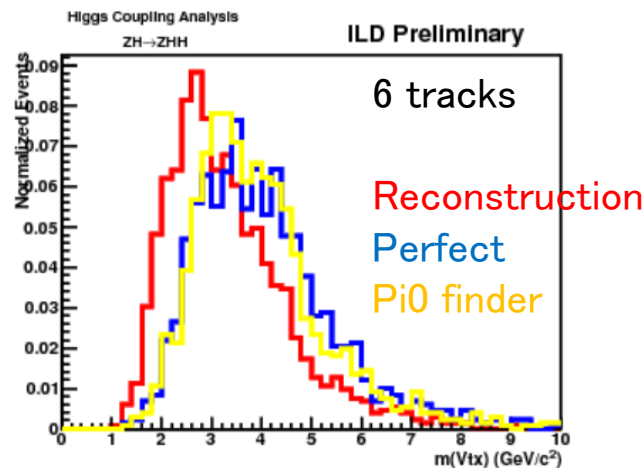
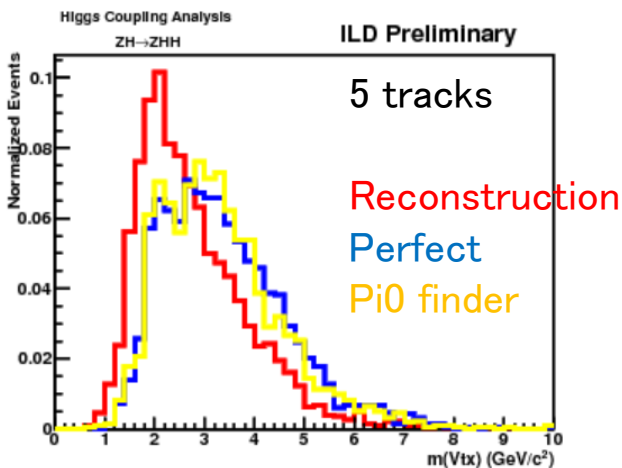
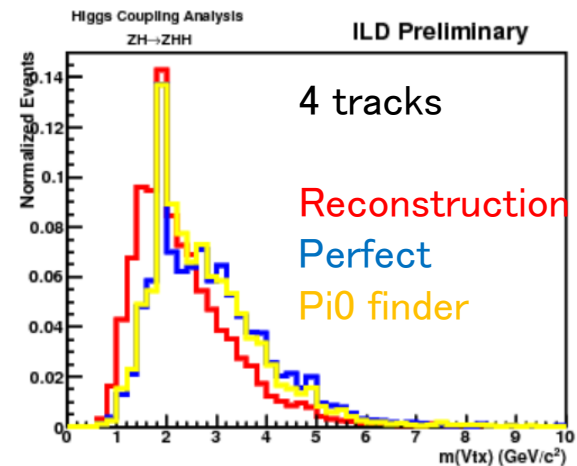
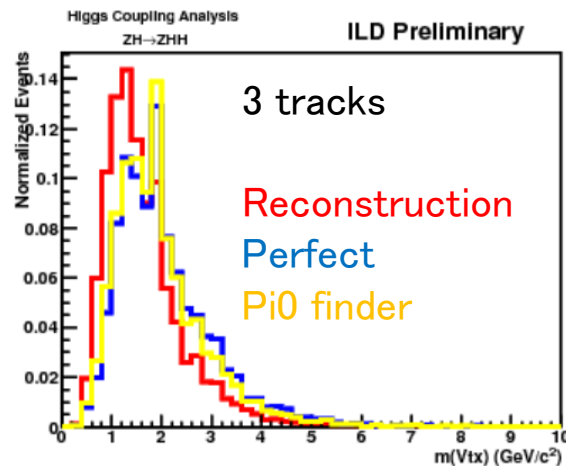
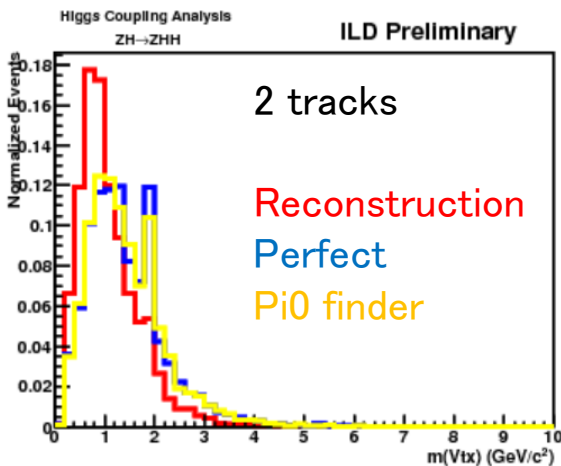
- Signal: π^0 s from secondary vertices which don't have third vertex
- Background: π^0 s from primary (L_{decay} from IP $< 0.3\text{mm}$)
- All the π^0 s are assumed to come from secondary vertex
 - Correct gammas & π^0 momentum
- Using Gradient BDT
- MVAcut > 0.79 ($n_{\text{trk}} \geq 3$)
 > 0.69 ($n_{\text{trk}} = 2$)



VTX MASSES

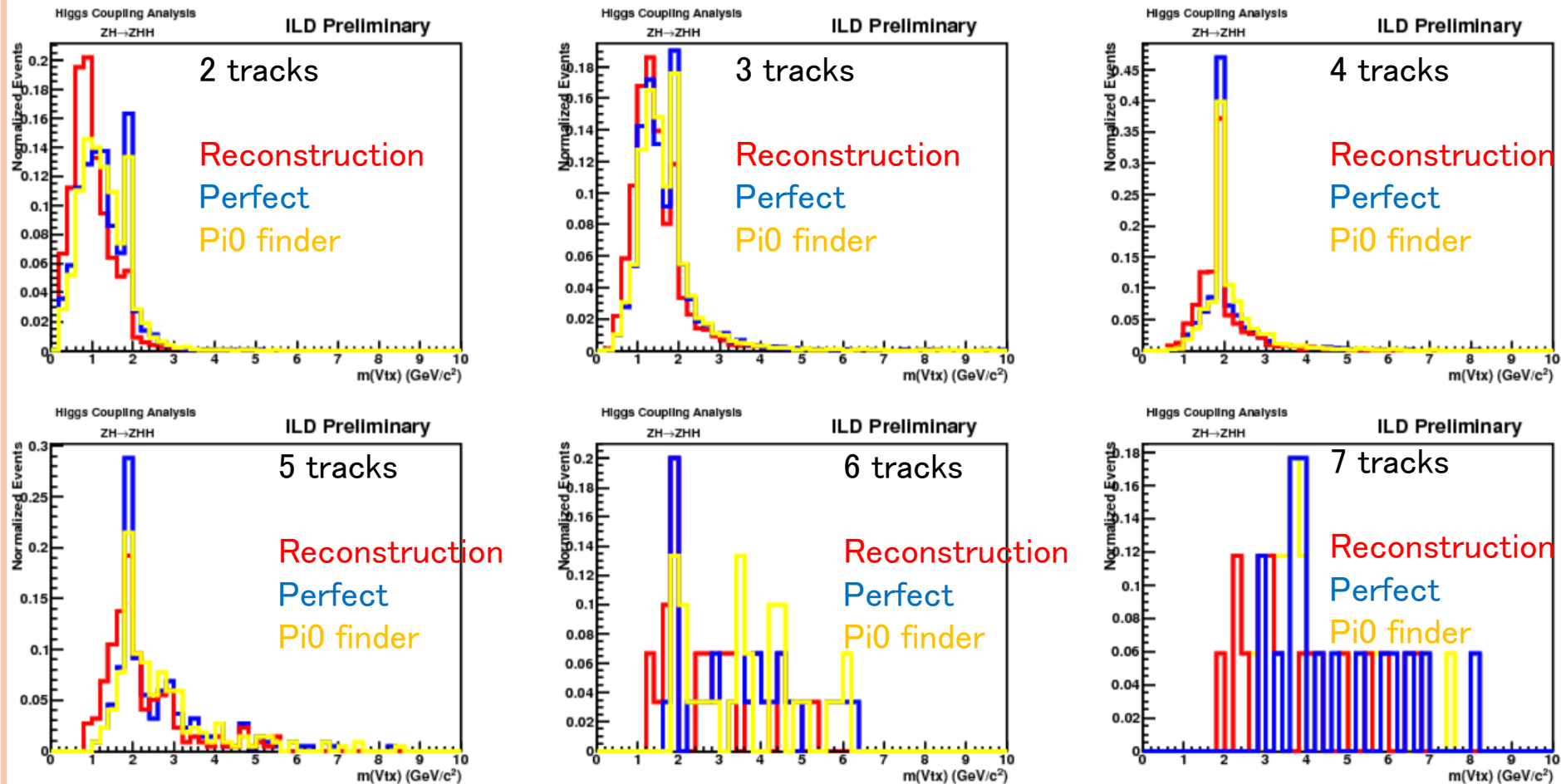
○ Vtx mass distributions for each vertex pattern(ntrk)

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



TESTING OF C VERTEX CASE

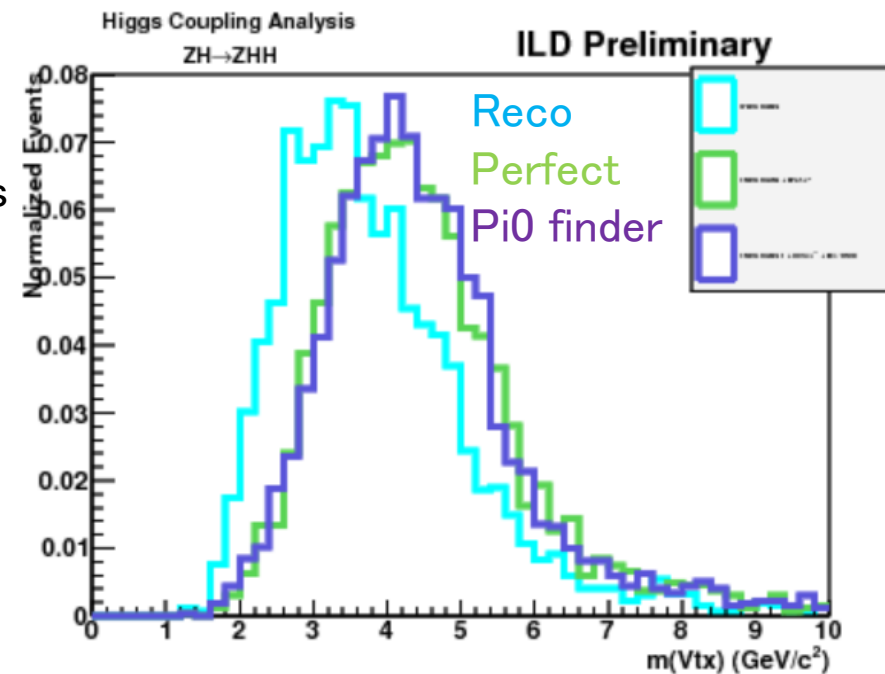
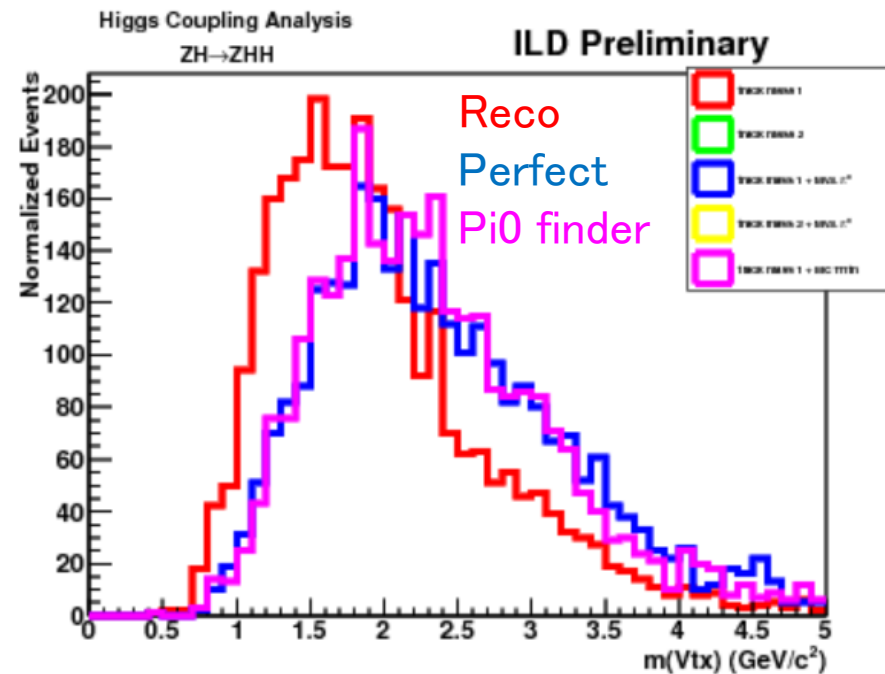
- Attaching pi0s to c vertex using same classifier
 - So far, no strange behavior



GLANCE AT OTHER CASE

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

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



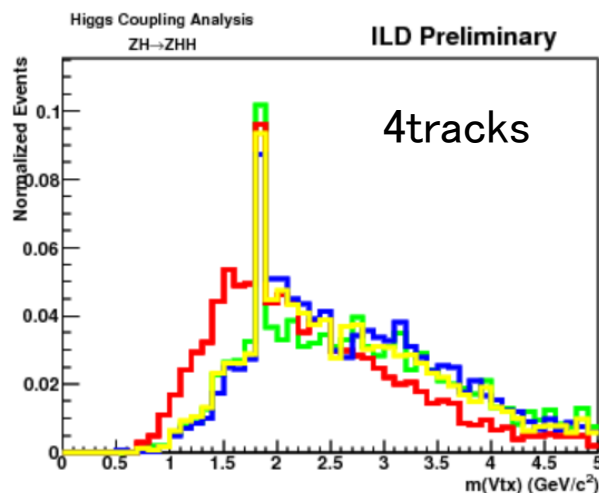
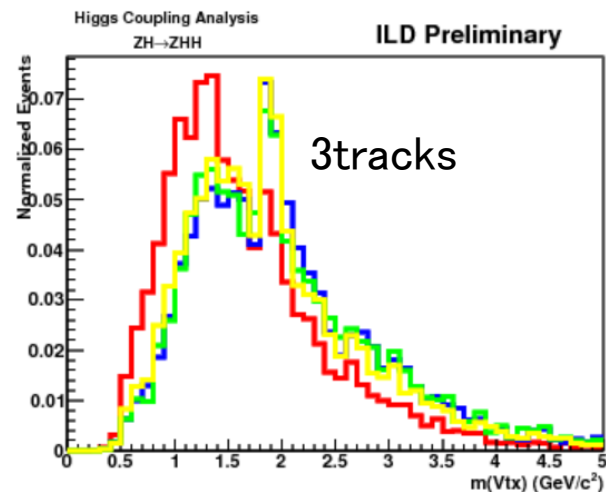
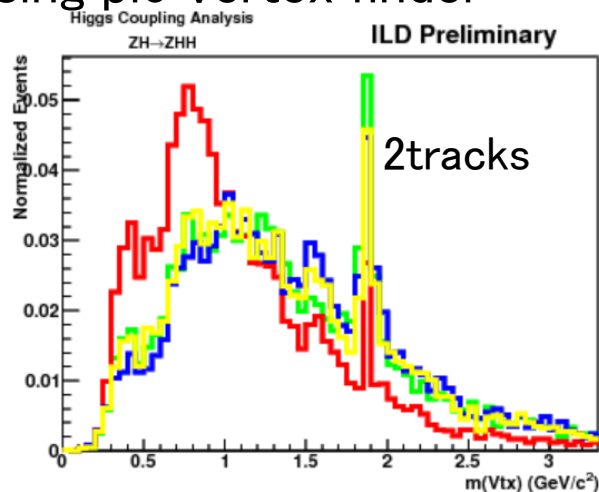
THE MOST REALISTIC SITUATION

- After an event occurs, we only measure:
 - Charged particle information – 4-momentum, and particle type(PID)
 - Neutral particle information – 4-momentum of **gamma or stable hadrons**
 - We have no direct information of π^0 s
- We need to get π^0 information from gammas!
 - Gamma finder – choosing gamma candidates from neutral particles
 - π^0 reconstruction – gamma pairing from gamma candidates
- In such situation, **how is the vertex mass recovery?**
 - How is neutral hadron contamination effect?
 - How is gamma mis-pairing effect?
- About π^0 reconstruction, I have already talked at previous talk
- By using that π^0 reconstruction, attaching π^0 candidates and compare the vertex mass

MOST REALISTIC SITUATION

○ Pi0 is constructed from PFO

- Using gamma finder
- Using pi0 reconstruction
- Using pi0 vertex finder



Reconstruction

Pairing & pi0 attachment perfect

Pairing perfect

Realistic situation

VERTEX MASS RECOVERY EFFECT ON FLAVOR TAGGING

○ Can vertex mass recovery really improve flavor tagging?

- Try to construct flavor tagger using recovered vtx mass!
- Note: this flavor tagger is very “toy” flavor tagger!

○ First, checking single variable separation power $\langle S^2 \rangle$:

$$\langle S^2 \rangle = \frac{1}{2} \int \frac{(S(y)-B(y))^2}{S(y)+B(y)} dy$$

- $\langle S^2 \rangle$ is from 0 to 1: 0 is no separation and 1 is perfectly separated

bc separation	Old vtxmass	Recovered vtxmass
2 nd vtx (use 1vtx jet)	0.1654	0.2756
2 nd vtx (use 2vtx jet)	0.2660	0.2870
3 rd vtx (use 2vtx jet)	0.2714	0.3211
bl separation	Old vtxmass	Recovered vtxmass
2 nd vtx (use 1vtx jet)	0.1652	0.1618

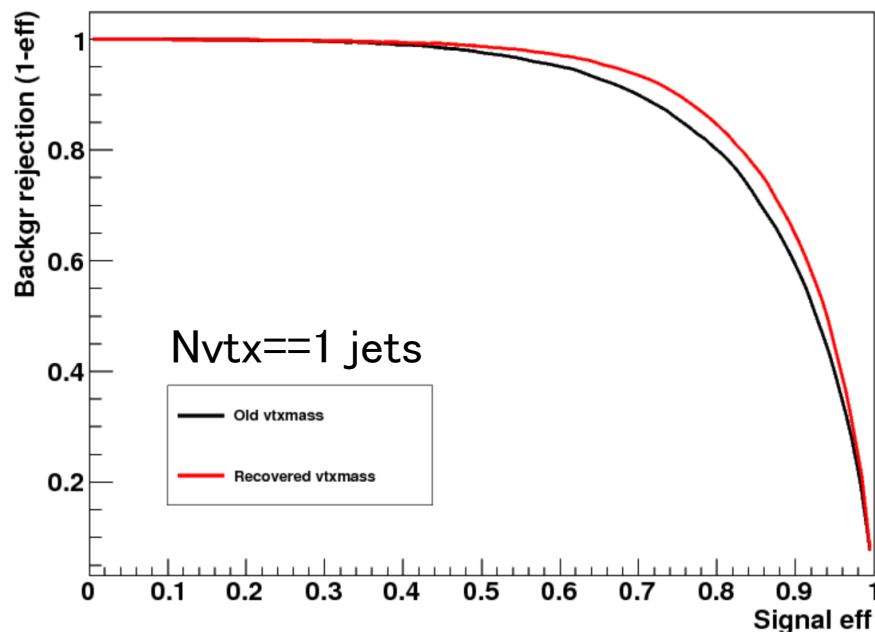
- In b jet vs. l jet case, l jet statistics is too low

VERTEX MASS RECOVERY EFFECT ON FLAVOR TAGGING

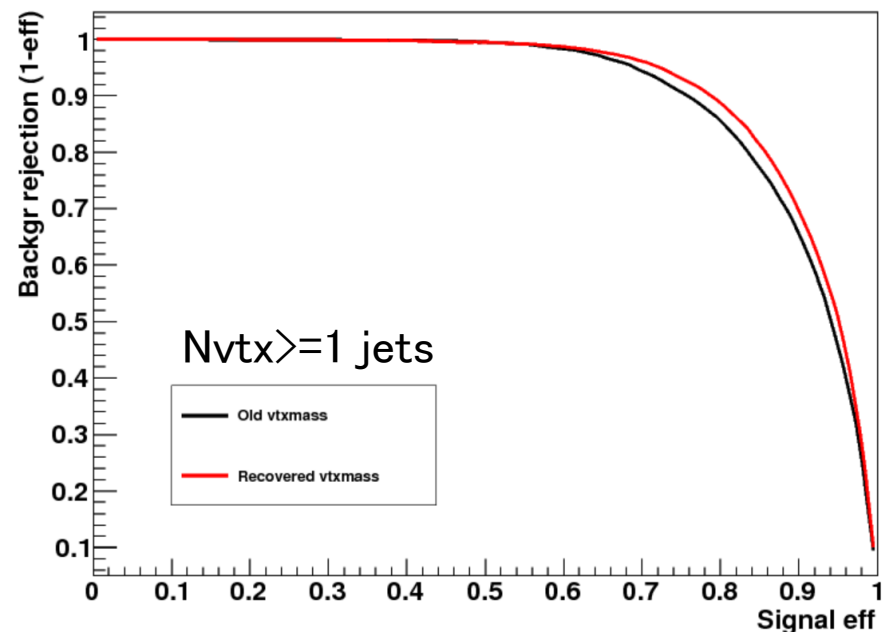
○ Construct a “toy” flavor tagger

- Input variables are obtained from LCFIPlus
- Input variable selection is too primitive!
- Only vertex mass is replaced to recovered vertex mass
- Compare with ROC curve

MVA_BDTG_flavortagger_bcseparation



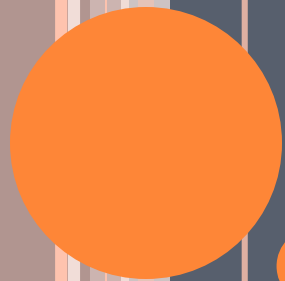
MVA_BDTG_flavortagger_bcseparation



○ For more precise study, need to step into LCFIPlus

SUMMARY, PROBLEMS AND PROSPECTS

- 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
- In realistic situation, π^0 vertex finder has robustness
 - π^0 gamma mis-pairing effect is small
- Vertex mass recovery will provide better separation on b/c jets!
 - Single variable separation power improves well
 - Recovered vertex mass seems to bring better flavor tagger!
 - Need precise study in LCFIPlus
- Finally, check the flavor tagging effs. in LCFIPlus!
- Next: Is there room in 0 vertex jet case? (particle ID is KEY!)



BACKUPS



16



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

