Constructing Pi0 Finder

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- For flavor tagging improvement
  - Vertex mass is the key to separate heavy/light flavor vertex
  - Many pi0s will escape from B/D vertex → checked that using MC truth
  - Mass resolution will be degrade due to escaping neutrals
  - Is there possibility to recover pi0s 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?

- Second step is to reconstruct pi0s – pairing of 2 gammas
  - Similar to jet pairing
  - Using Bayesian approach(naïve Bayes)
  - Checking good pairing eff. & mis-pairing eff.

Gamma Pairing

- Using naïve Bayes
  - Posterior probability:

$$P(\pi^0|x) = \frac{P(x|\pi^0)\cdot P(\pi^0)}{P(x)} = \frac{P(x|\pi^0)\cdot P(\pi^0)}{P(x|\pi^0)\cdot P(\pi^0) + P(x|wrong)\cdot P(wrong)}$$

  - Identify as gamma pair from pi0 with $P(\pi^0|x)$>threshold (need to optimize)

- Key point: pi0 decay kinematics

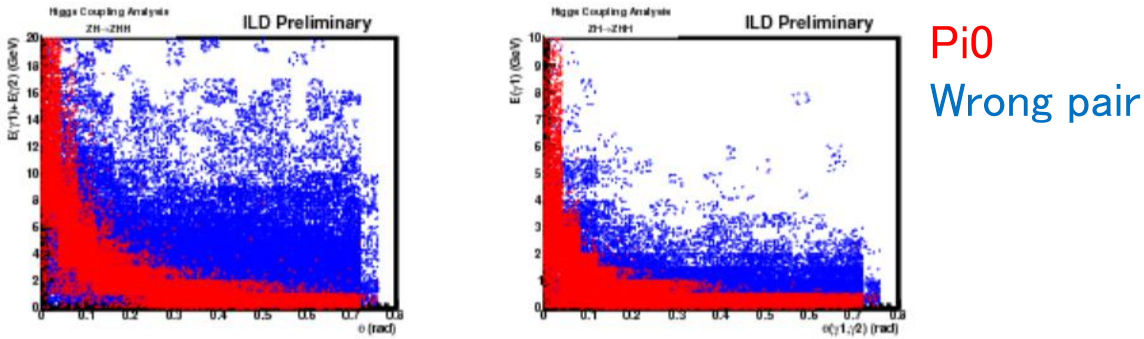
$$m_{\pi^0}^2 = 2E_{\gamma 1}E_{\gamma 2}(1-\cos\theta)$$

  - So, 2gammas' variables are highly correlated

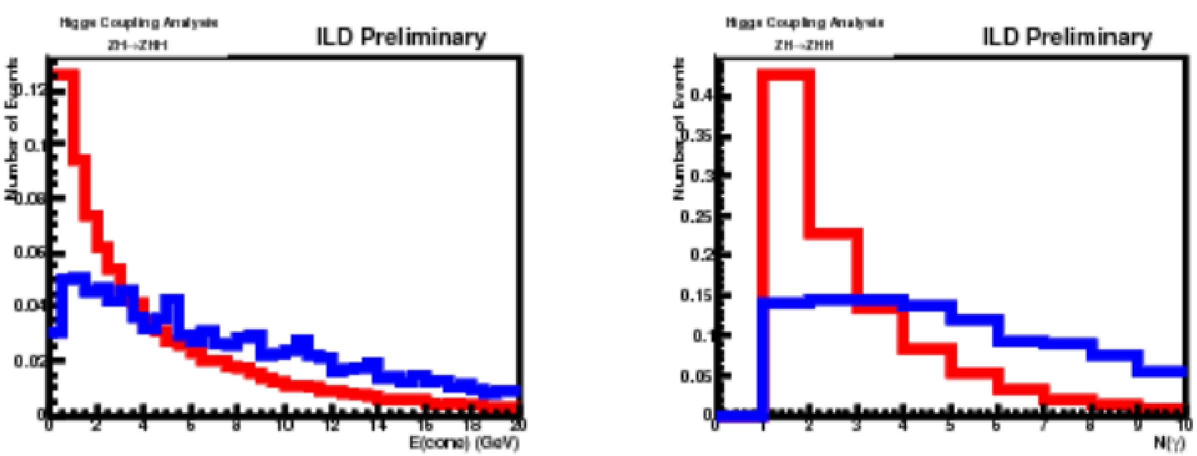
- Avoid mis-pairing when many gammas are located in very small area
  - In many case, pi0s are flying in same direction!
  - So far, no very nice idea…

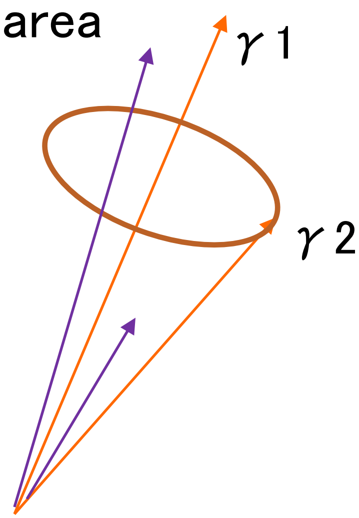
For this analysis

- Introducing 2D-likelihood
  - Includes correlation effect
  - $E(\gamma 1)+E(\gamma 2)$ v.s. θ & $E(\gamma 2)$ v.s. θ
  - p.d.f.s from these distributions



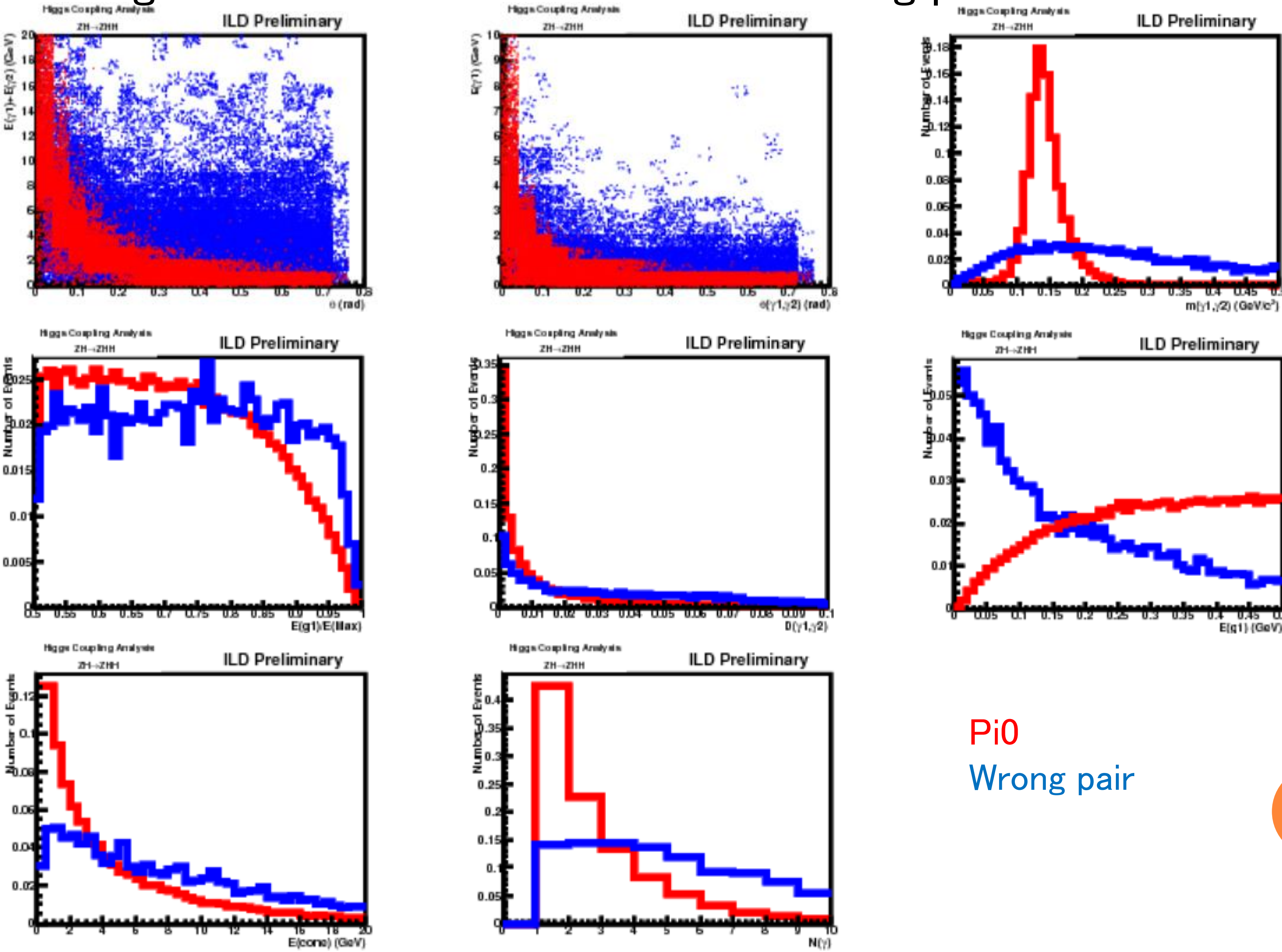
- Distribution of other gammas inside the cone of decay angle
  - To avoid mis-pairing of gammas located in small area





Variables to be used

- Signal: pi0s from primary vertex(L_{decay}<0.3mm)
- Background: all the combinations of wrong pairs



Pi0
Wrong pair

Problem of pi0 reconstruction in the events

- Pi0 reconstruction: maximize likelihood(minimize χ^2) globally in the event
- If, num. of pi0s in the event is known, it is very easy!
- Big problem: **num. of pi0s in the event is a free parameter!!!**
- **So, trivial answer to meet the condition(maximum likelihood) IS:**

  →no pi0s in the event!! (Likelihood is of course 0(max)!)

- To avoid it: impose a penalty for unpaired gammas
- So define the information criterion:

$$IC = -2 \sum \log L(\pi^0) + k \cdot N(unpaired\,\gamma)$$

- Gamma pairing is performed according to IC:

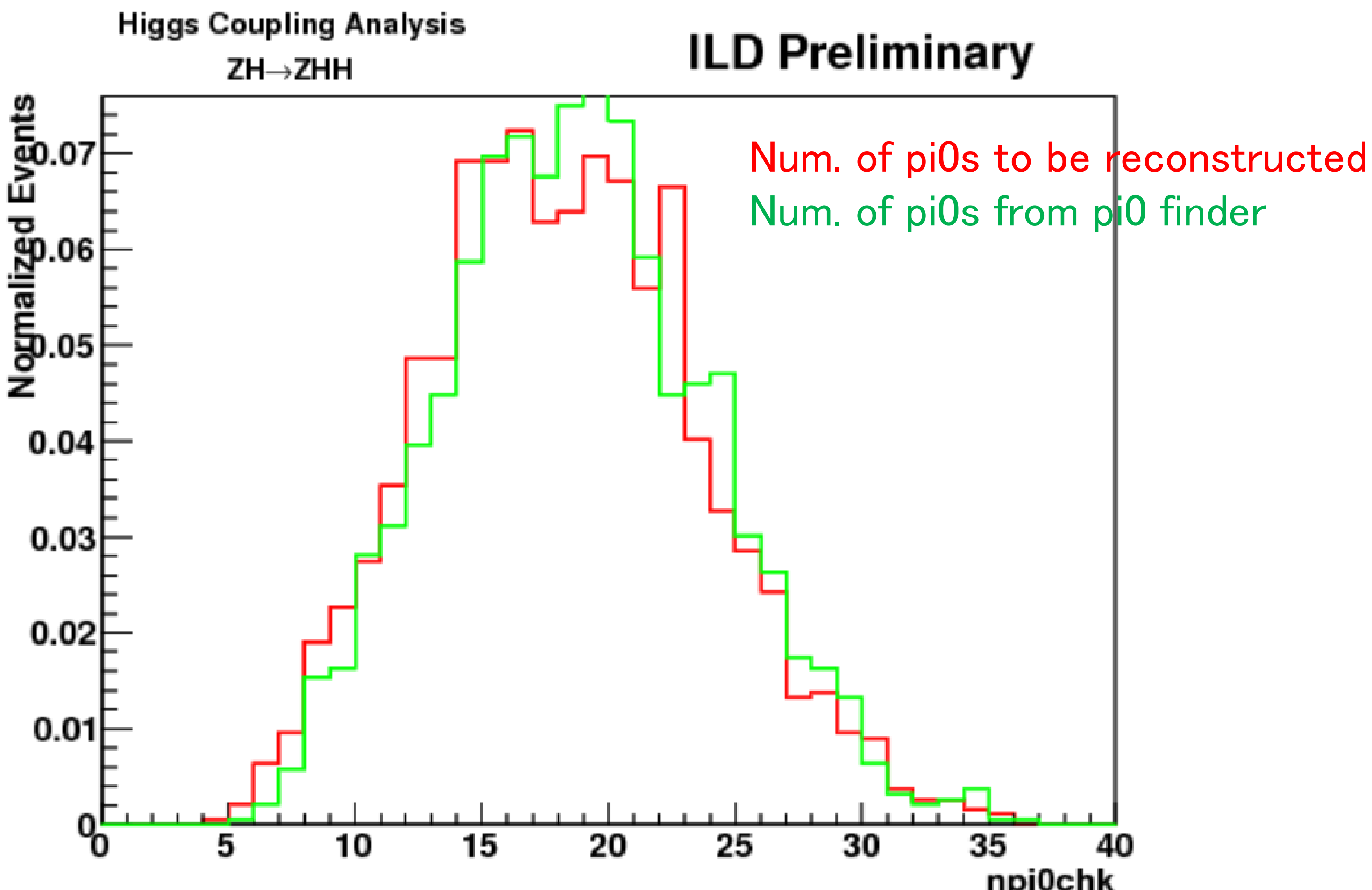
  →minimize IC

- If k(>0.0) is large, pairing of gammas is boosted

  →it is necessary to optimize k!

K OPTIMIZATION SO FAR

- K will be set at the point where num. of pi0s are almost same as the capacity of pi0 reconstruction matched with MC truth
- Set $k = 0.03 \cdot \log N(\gamma)$



RESULTS

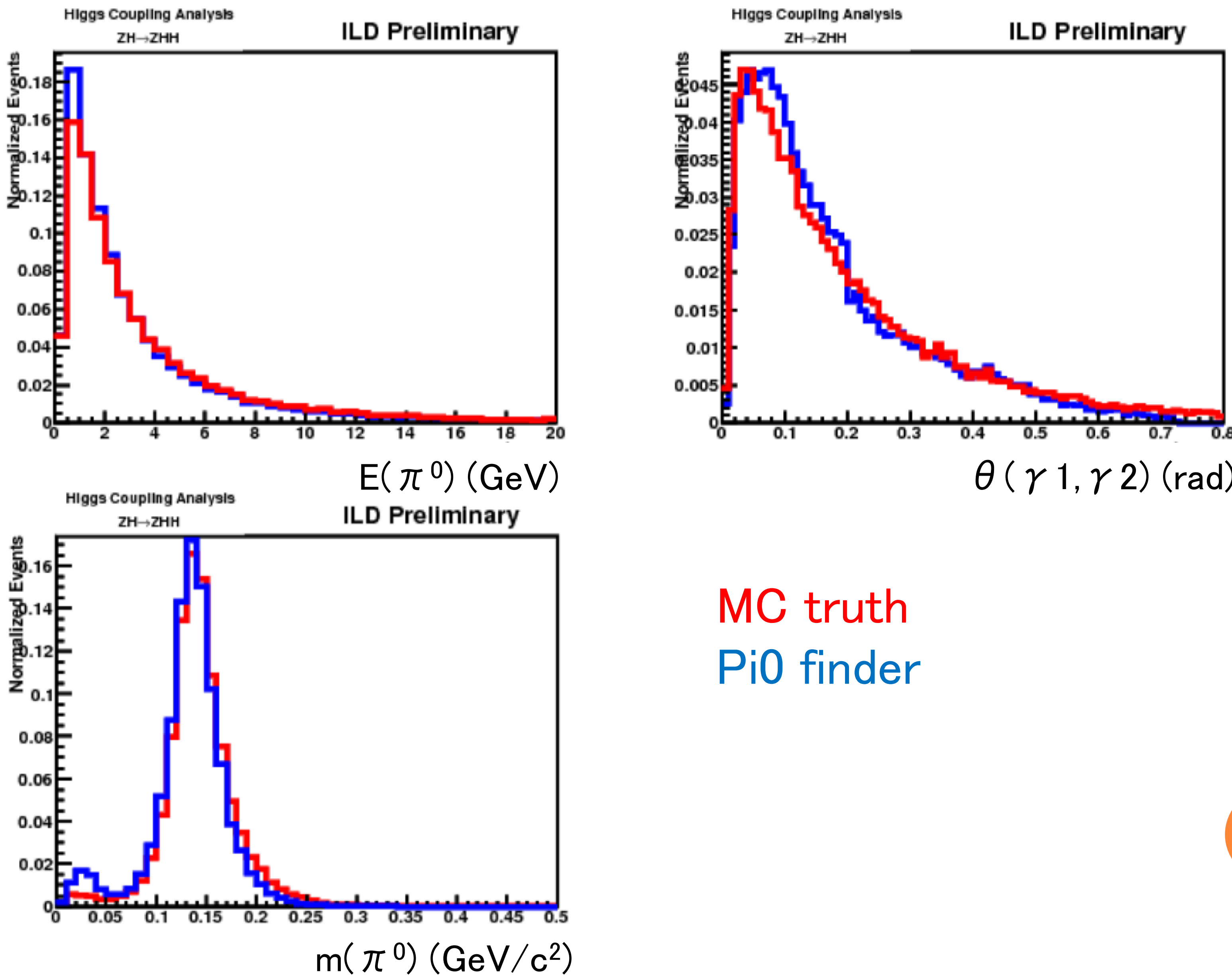
- Good pairing eff. & mis-pairing eff.

	Correct pair	Wrong pair
eff. (%)	46.0±0.3	54.0±0.4

- Bad pairing eff. is the problem…
  - When gammas are located in small area
  - In many case, gammas tend to jam in small area
- Need to check the degradation when neutral hadrons are contaminated

Checking kinematics

- Pi0 decay kinematics



TODO

- Method to minimization(maximization)
  - Do I really get minimized IC? →algorithm for minimization
  - IC is a good estimator?

- I don't know how to improve gamma pairing eff.…
  - Only ～50% so far