Higgs self-coupling analysis with H→WW*

Masakazu Kurata

03/07/2014

STATUS

- dE/dx – working with Astrid to digitize the dE/dx correctly
- Shower profile – going on
  - Correct some bugs
  - Start to apply shower profile to lepton ID
  - Trying to integrate Ecal/Hcal correctly
    - So far, Hcal is not considered correctly
    - Not yet included because there are some problems
- Trying jet paring using Bayesian approach
  - Include angle information
  - Jet pairing for $WW \rightarrow jjjj$
  - Jet pairing for $ZH \rightarrow bbbb$

dE/dx

dE/dx

- working with Astrid to digitize the dE/dx correctly
  - Check the landau tail effect
    - Does Landau tail effect input correctly on simulation?
  - Check the fluctuation of dE/dx – not yet
    - With several particles and momentum range

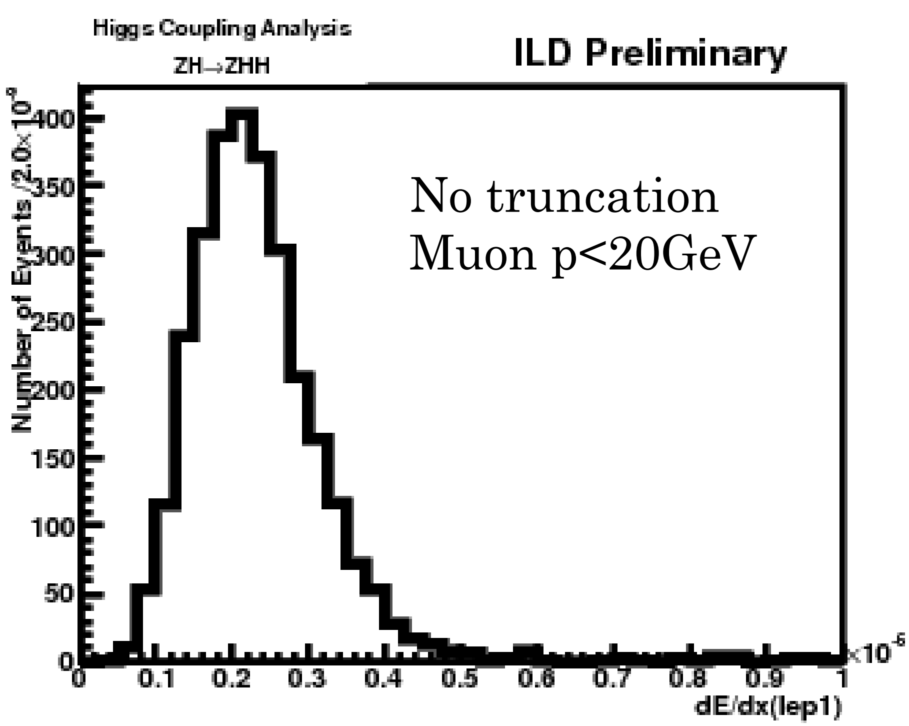
- dE/dx definition:
  - $\frac{dE}{dx} = \frac{energy\ deposit}{flight\ path\ in\ the\ hit(TPC)}$
  - dE/dx can be calculated at any hit point
  - Truncated mean is calculated as track dE/dx

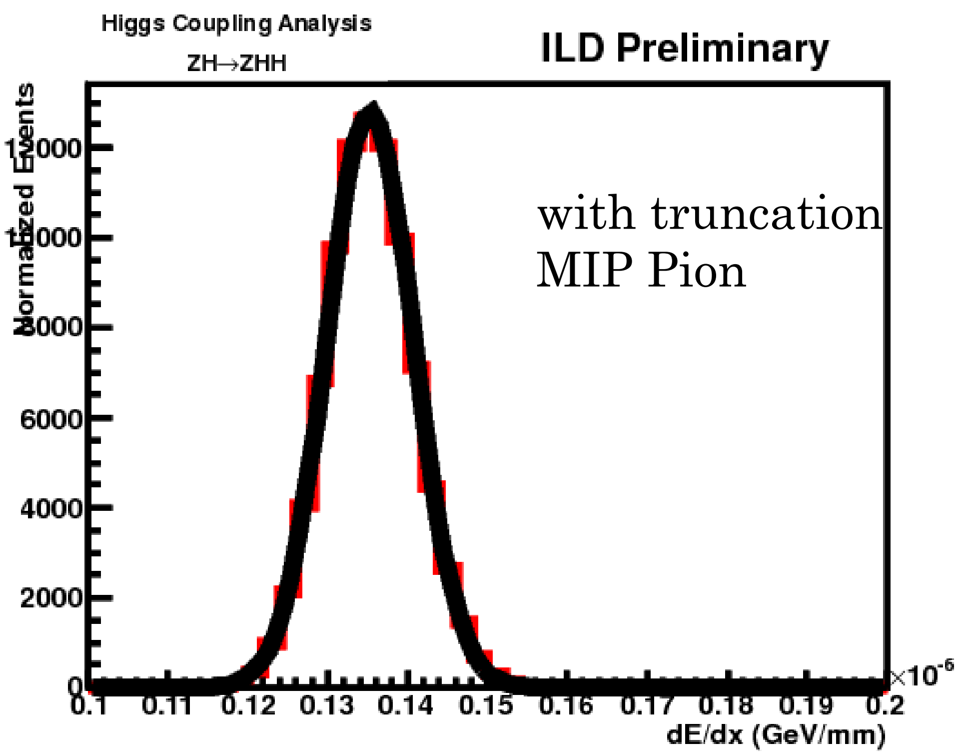
  $\left\langle \frac{dE}{dx} \right\rangle = \sum_i^n \frac{dE_i}{dx_i}$ upper 30%, lower 8% hits are discarded to avoid Landau tail

  →optimization is necessary

Effect of Landau tail

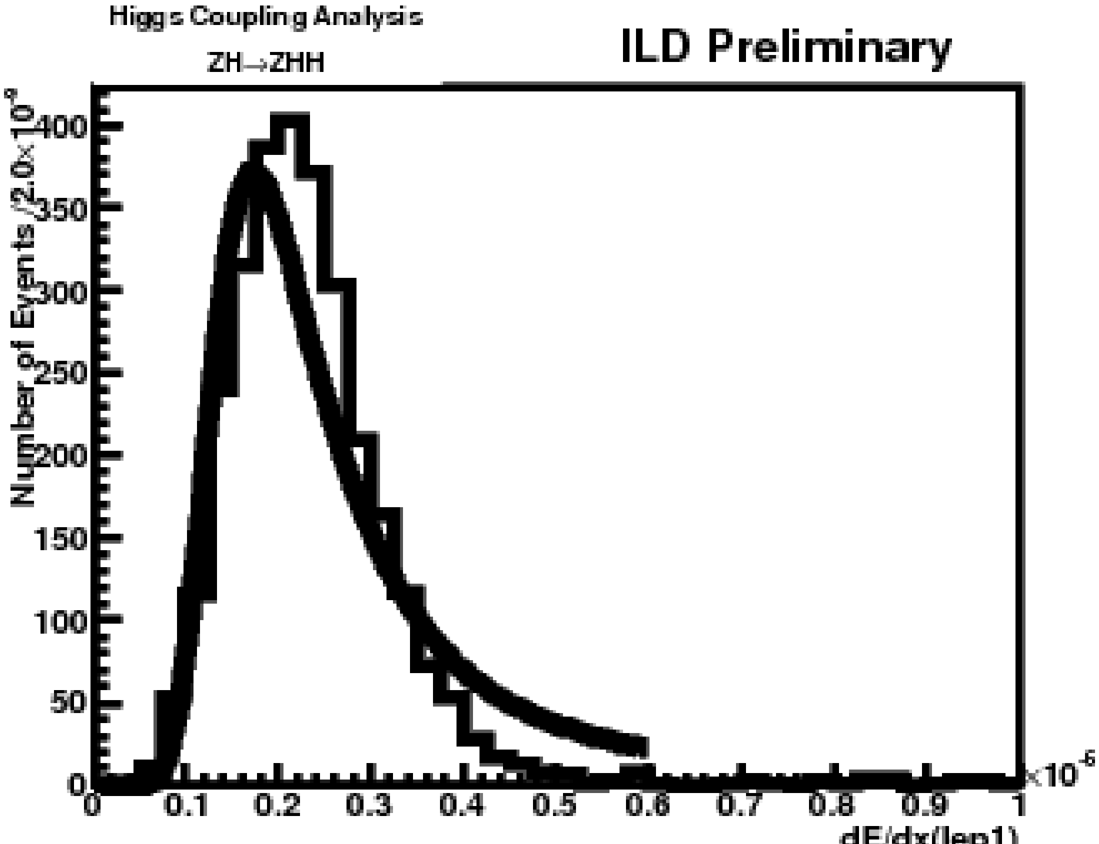
- Landau tail effect
  - Mean of w/w.o. truncation
  - Tail can be seen in the case of no truncation





BUT…

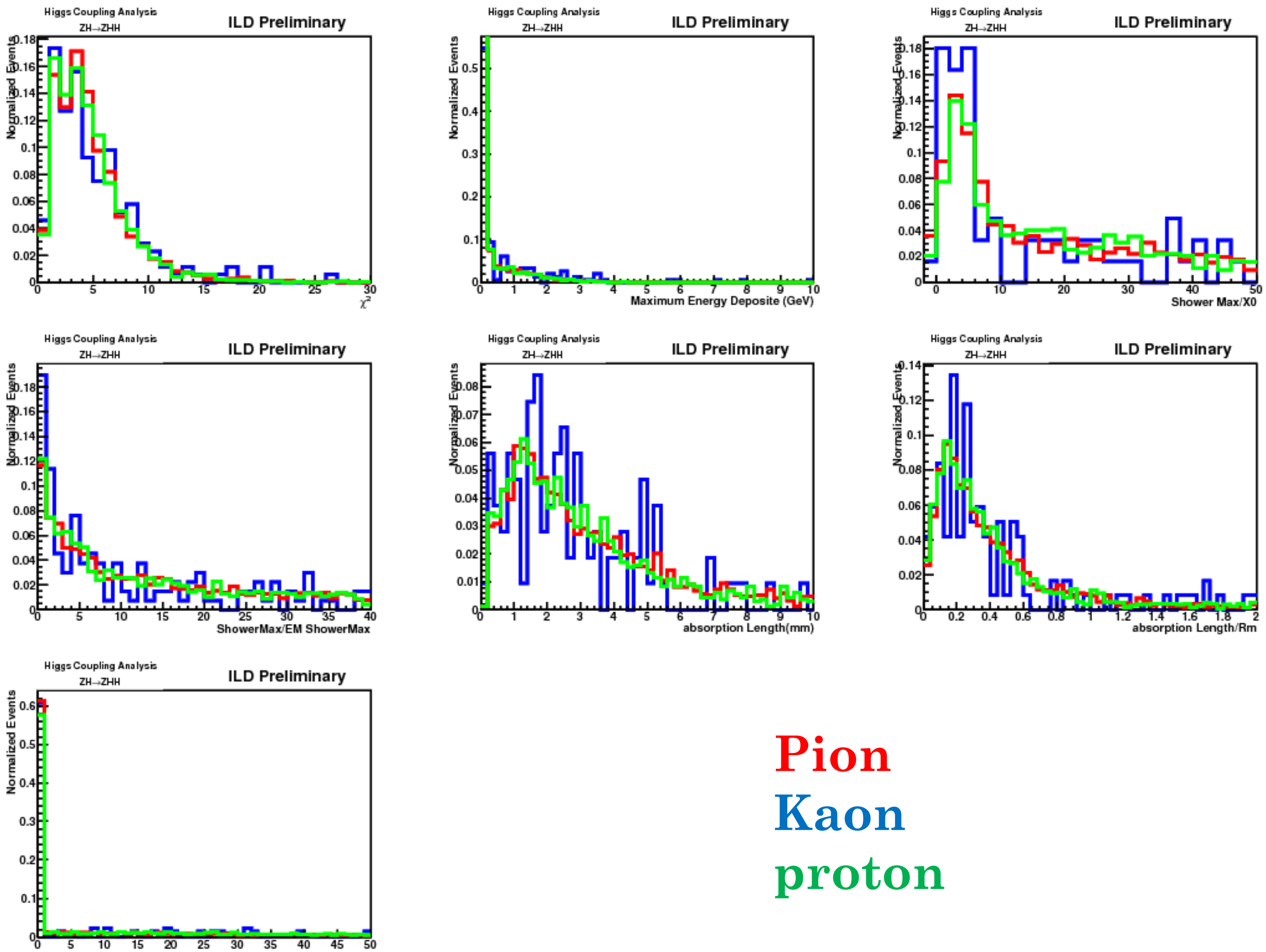
- The distribution doesn't fit well to Landau function…
  - Why?
  - Simulation is wrong?
  - So far, checking bugs…



Shower profile

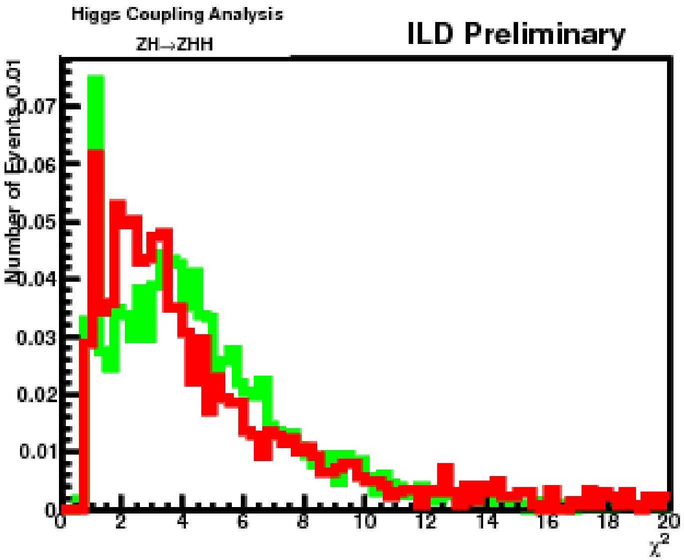
FAKE LEPTON CHECK

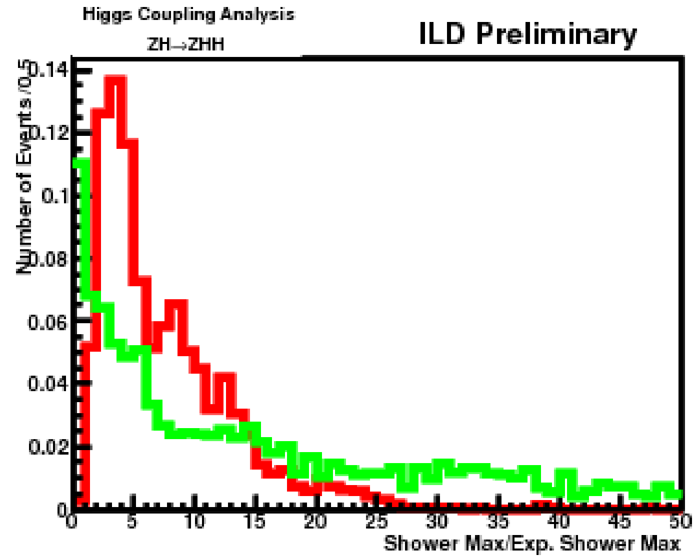
- Check the particle type of the fake lepton candidates
  - Electron type
    - No difference found – so far all-in-one as fake leptons

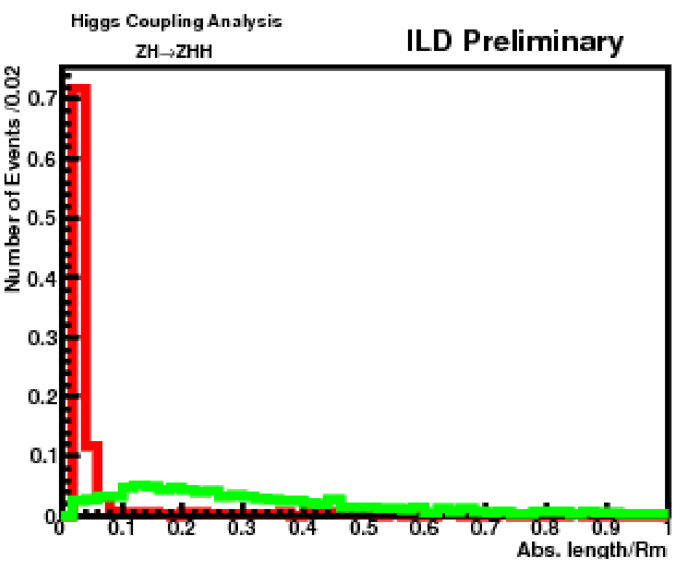


Shower profile tried for Lepton ID

- Electron type







Isolated Lepton
Fake Lepton(Hadron track)
※no soft lepton included

LEPTON ID USING SHOWER PROFILE

- Try to include shower profile to lepton ID
  - Lepton ID is based on the likelihood method
  - $L = \frac{\prod s}{\prod s + \prod b}$ s and b are the p.d.f.s of signal and backgrounds
  - Compare the results at same signal efficiency
    - Same signal efficiency as the cut based lepton ID
    - Signal efficiency is ~98%
    - My target is the detection of the leptons from HH→(bb)(WW)→bblvjj

- Preliminary results – electron type

	Cut based	Old likelihood	w/ Shower profile
signal	98.4	98.1	**98.1**
HH→(bb)(bb)	-	2.3	**1.9**

  - Background rejection improves well (~19%)
  - Need to check with all hadronic top events

Jet pairing

NAÏVE BAYES

- Bayesian probability – posterior probability when x is given

$$P(A|x) = \frac{P(x|A) \cdot P(A)}{P(x)}$$

P(x | A): likelihood(probability when x is given from class A)

P(A): prior probability of class A

P(x): probability of x (sum of all the classes)

- Bayesian classifier – regard x as the element of class A,
  - When P(A | x) is largest of all the classes
    - e.g. x belongs to A when P(A | x)>P(B | x), P(A | x)>P(C | x), etc.

Jet Paring using naïve Bayes

- Preparing binary classifier for all the combinations
  - e.g.) case of (bb)(bb) pairing – there are 6 combinations(1 is true(A) and 5 are false combinations)
  - 5 false combinations are ordered using cosine similarity – grouping in descending order(B1, B2,B3,B4,B5):

$$sim = \frac{v1 \cdot v2}{|v1||v2|}$$

  - Preparing 5 binary classifiers – true combi. vs. 5 groups of false combi.
  - Likelihood is based on the linear discriminant analysis and make p.d.f.
- True combination is regarded as the one which is:
  - $P1(A|x)>P1(B1|x)$, $P2(A|x)>P2(B2|x)$, $P3(A|x)>P3(B3|x)$, $P4(A|x)>P4(B4|x)$, $P5(A|x)>P5(B5|x)$
- If there is no good combination or are some good combinations, the best combination is defined as:
  - Maximum of

$$\frac{P1(A|x) \cdot P2(A|x) \cdot P3(A|x) \cdot P4(A|x) \cdot P5(A|x)}{P1(B1|x) \cdot P2(B2|x) \cdot P3(B3|x) \cdot P4(B4|x) \cdot P5(B5|x)}$$

Preliminary results

- WW→jjjj pairing case
  - Also check maximum likelihood using LDA
  - $\chi^2 = -2\log BW(m(j1j2)|m_W, \Gamma_W)$

Pairing type	χ^2	Just likelihood	Naïve Bayes
True positive(%)	60.2	70.1	**74.7**

  - Good improvement can be obtained!

- ZH→(bb)(bb) case
  - $\chi^2 = \frac{(m_1 - m_Z)^2}{\sigma_Z^2} + \frac{(m_2 - m_H)^2}{\sigma_H^2}$

Pairing type	χ^2	Just likelihood	Naïve Bayes
True positive(%)	56.6	59.8	**59.8**

  - Improve slightly thanks to the angle information
  - But, need more improvement…
    - No improvement even if using naïve Bayes…