



STUDY OF THE TRACK PROPERTIES FOR ANALYSIS IMPROVEMENT

Masakazu Kurata

04/19/2014

TOPICS

- Summary of the status of studying track properties
 - dE/dx (backup)
 - Shower profile(backup)
 - Electron type study
 - Muon type study
 - Muon fakes study
- Status of lepton ID including track properties
 - About muon type dE/dx
 - Preliminary results
- Extras – for future plan
- AWLC14 talk: talk @ simulation session
will talk @ Higgs/EWSB(so far, seems OK)



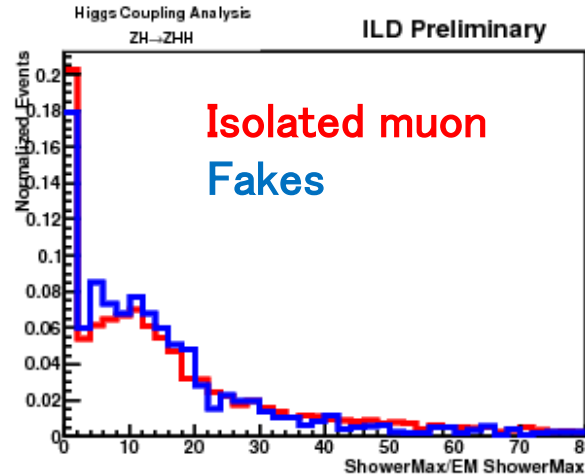
STUDY OF THE TRACK PROPERTIES FOR MUON TYPE

3

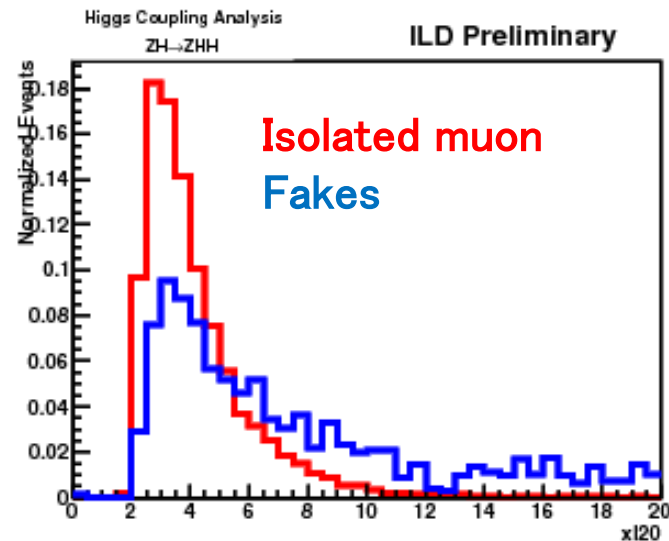
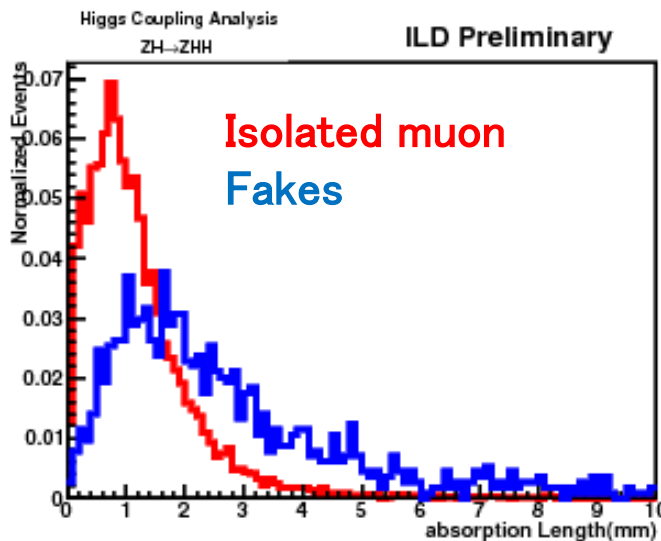
STUDY OF MUON TYPE

- Muon type fakes are very similar to the muon tracks

- Most of shower profiles are almost same distribution
e.g.) shower max

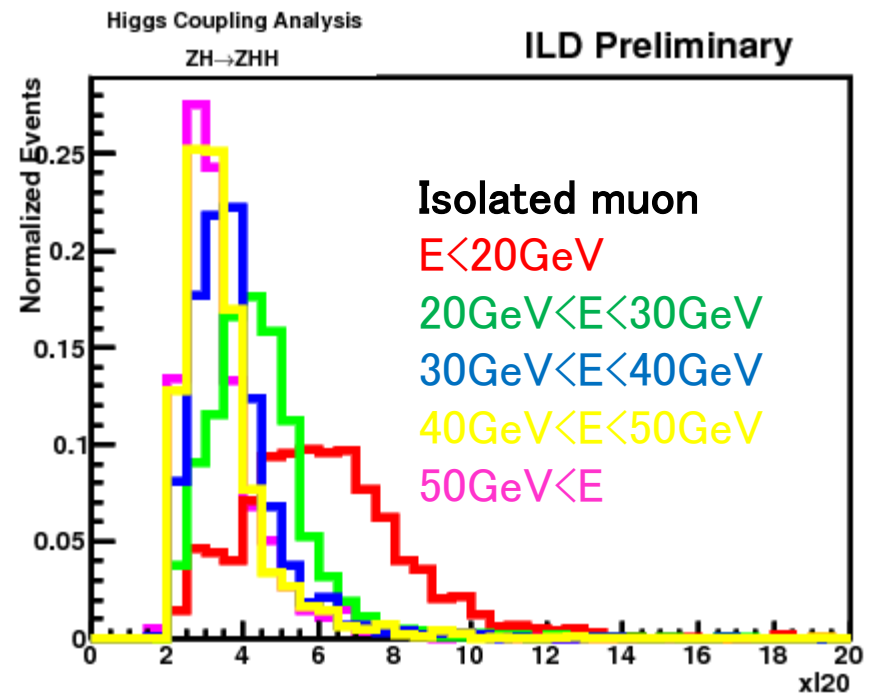
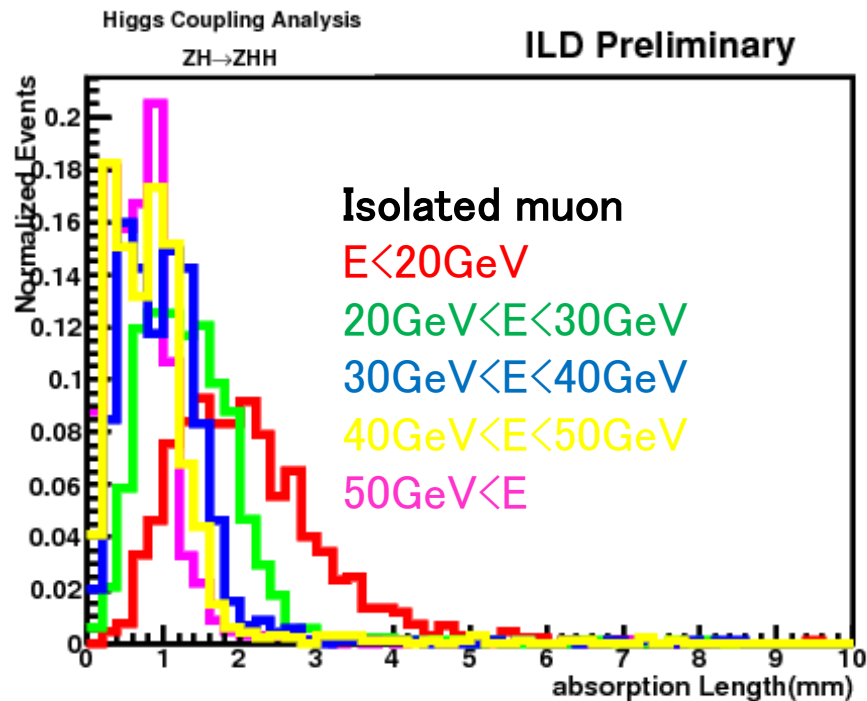


- Difference can be seen on absorption length & x120



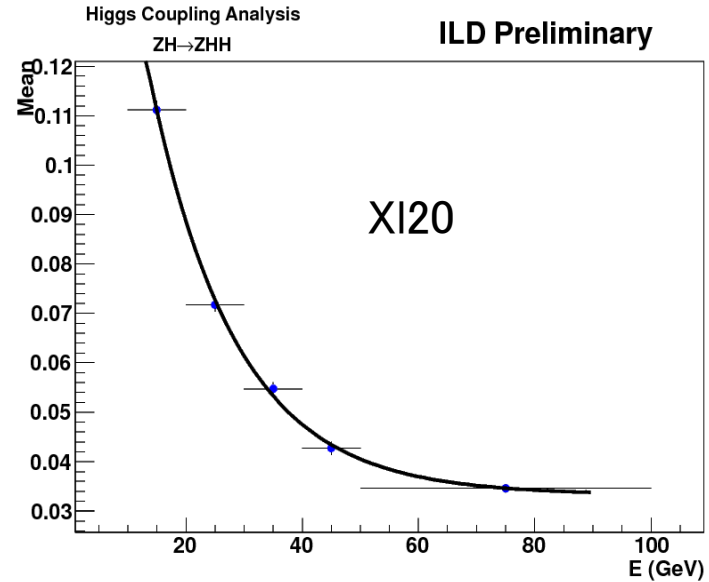
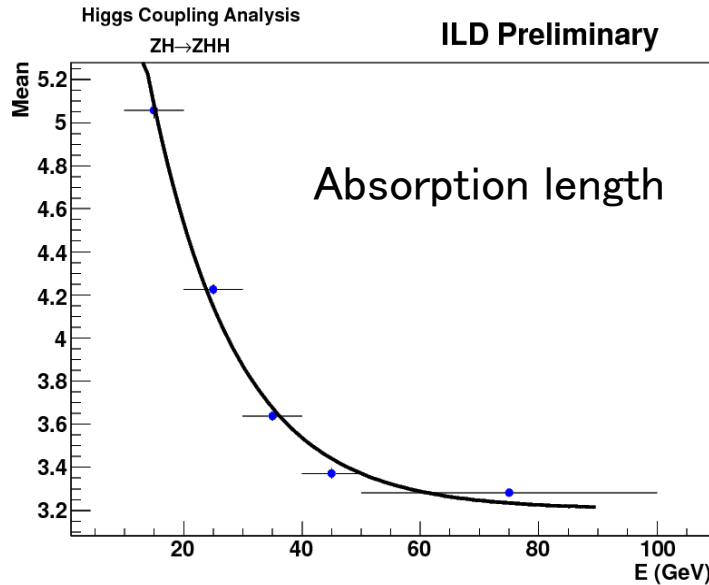
STUDY OF MUON TYPE

- But... there are strong momentum dependence
 - Due to the track curvature?

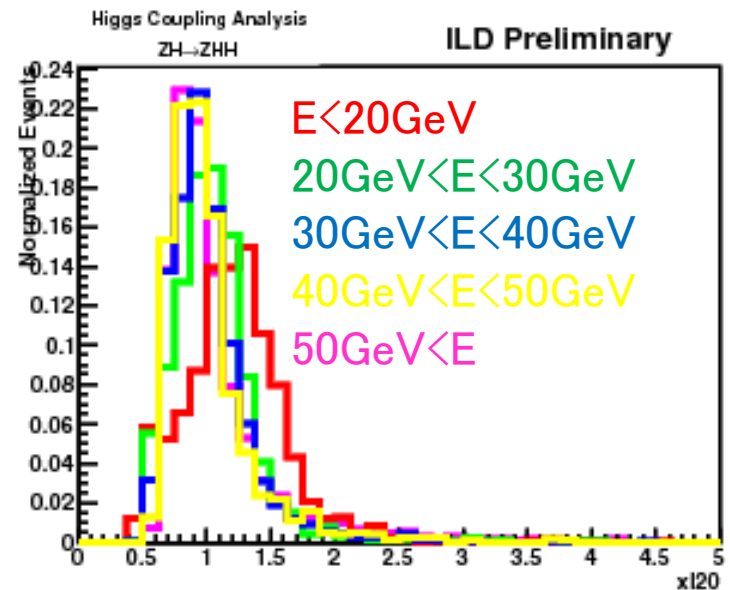
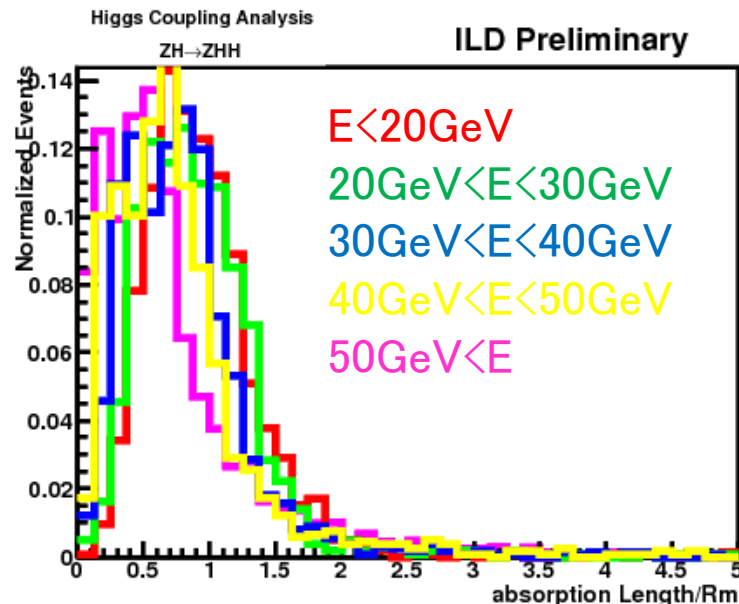


CORRECTION

- Mean is corrected to reduce the momentum dependence

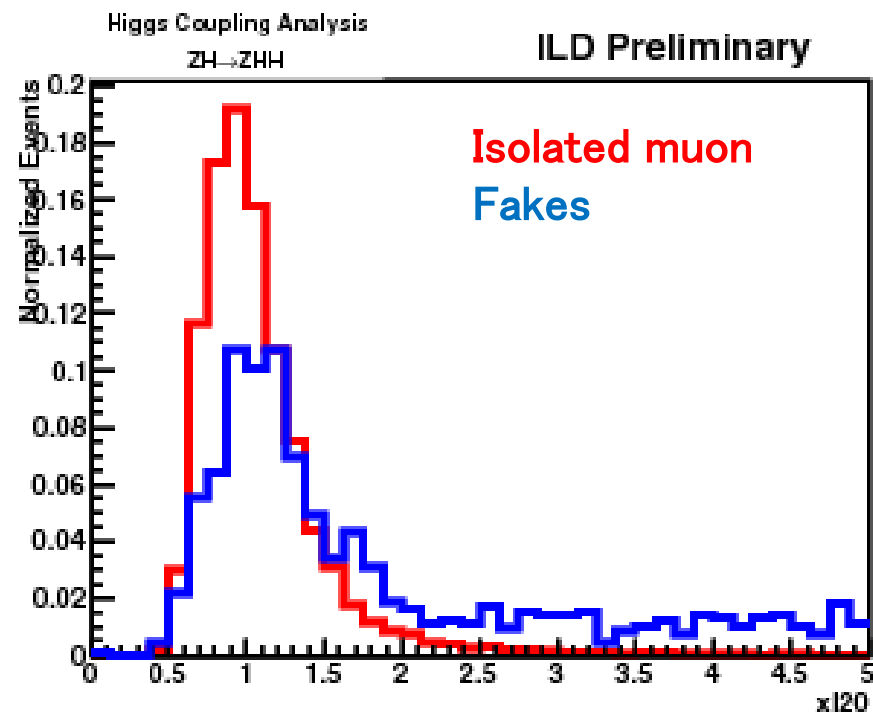
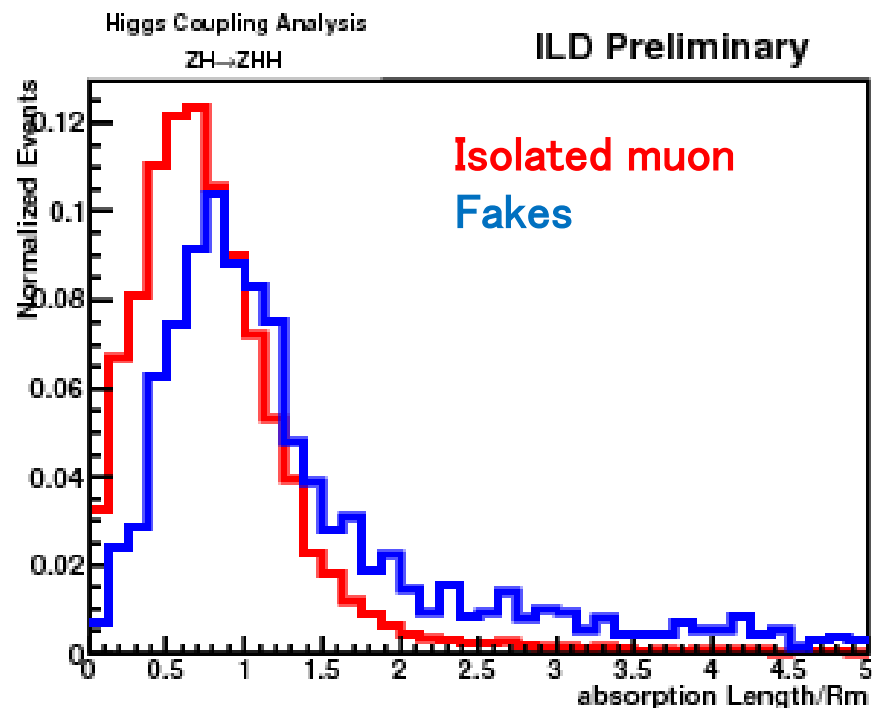


- After correction: much better. Dependence reduced



CORRECTED DISTRIBUTION

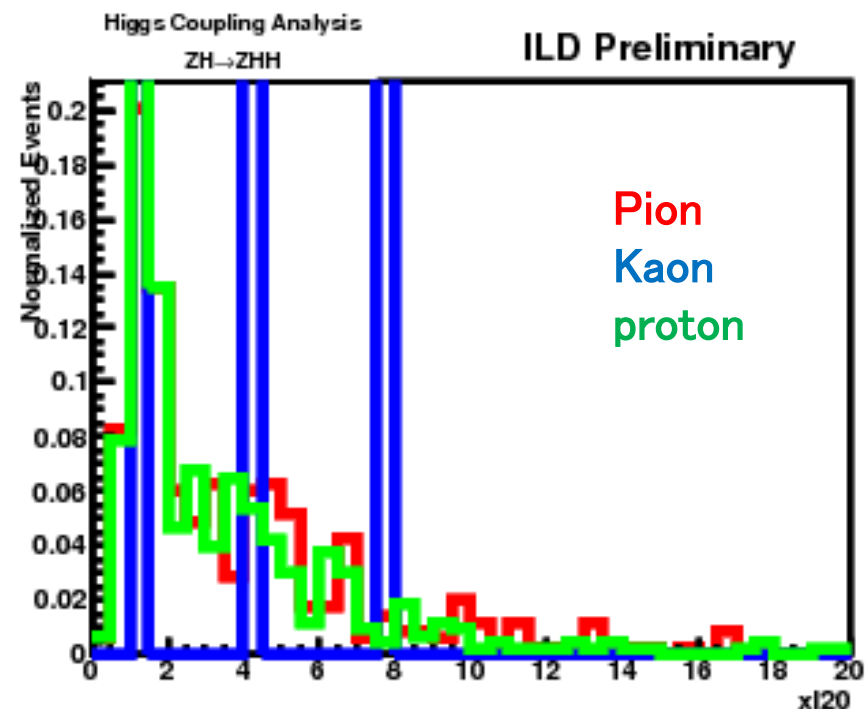
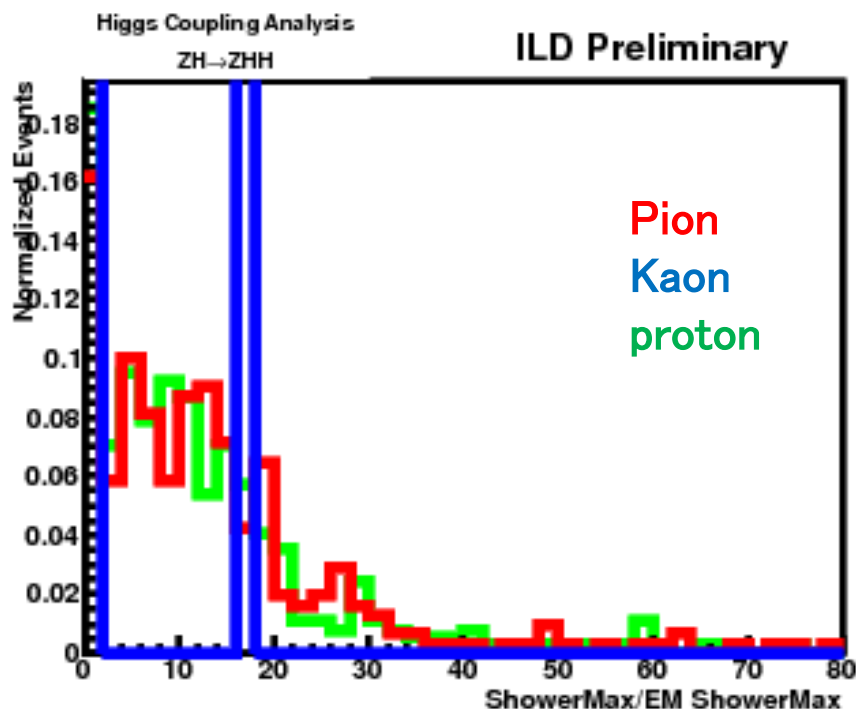
- Still have difference after correction
 - Good variable for lepton ID?



FAKE STUDY – EACH PARTICLE TYPE

○ Longitudinal information

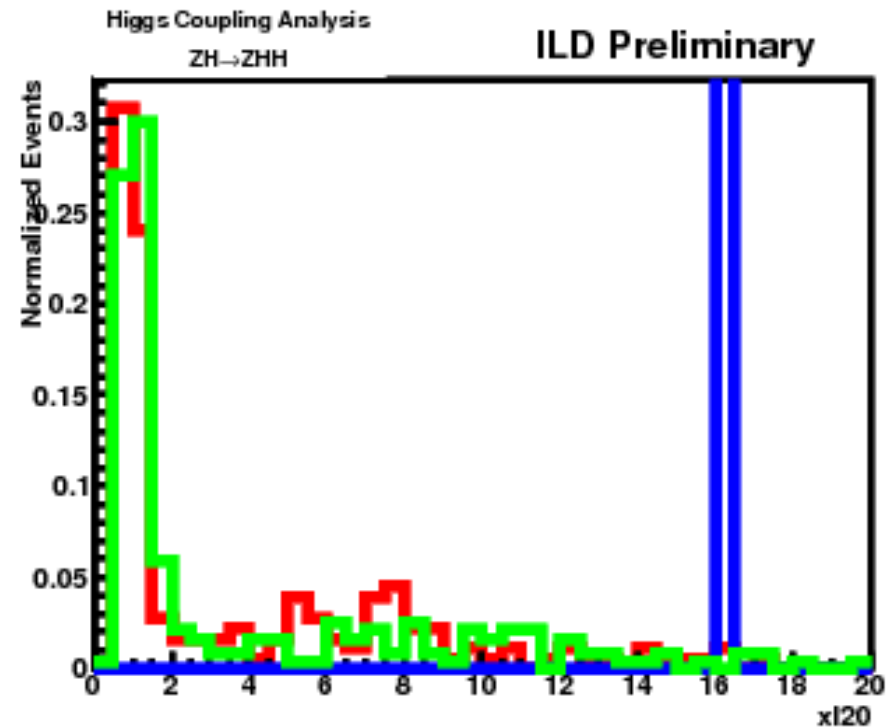
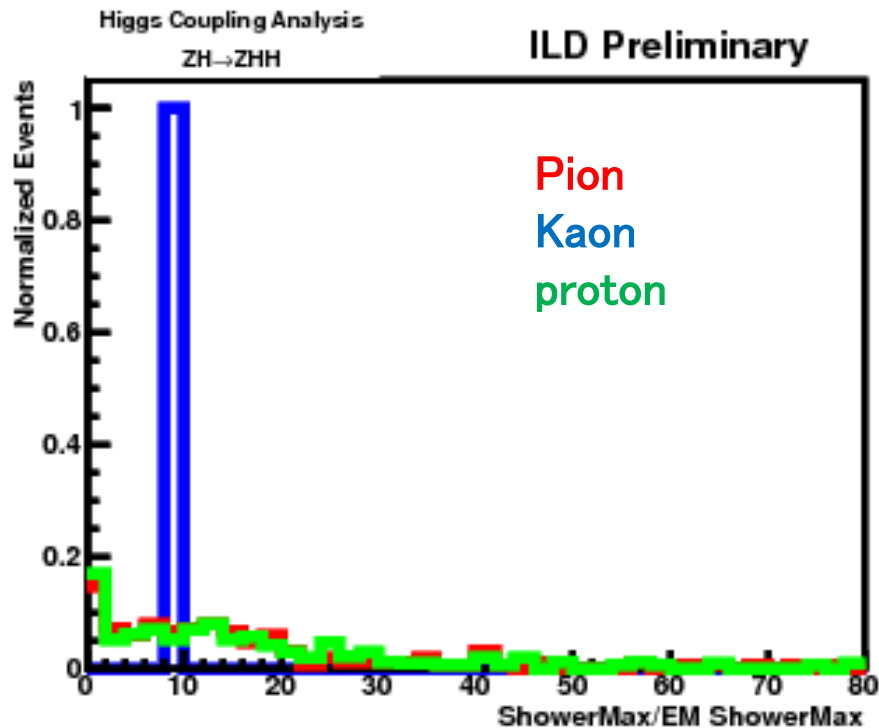
- Characterized with showerMax and xl20
- Low energy tracks $20\text{GeV} < E < 40\text{GeV}$
- showerMax is scaled using Exp. shower max
- Each particle type (π , K, p)



FAKE STUDY – EACH PARTICLE TYPE

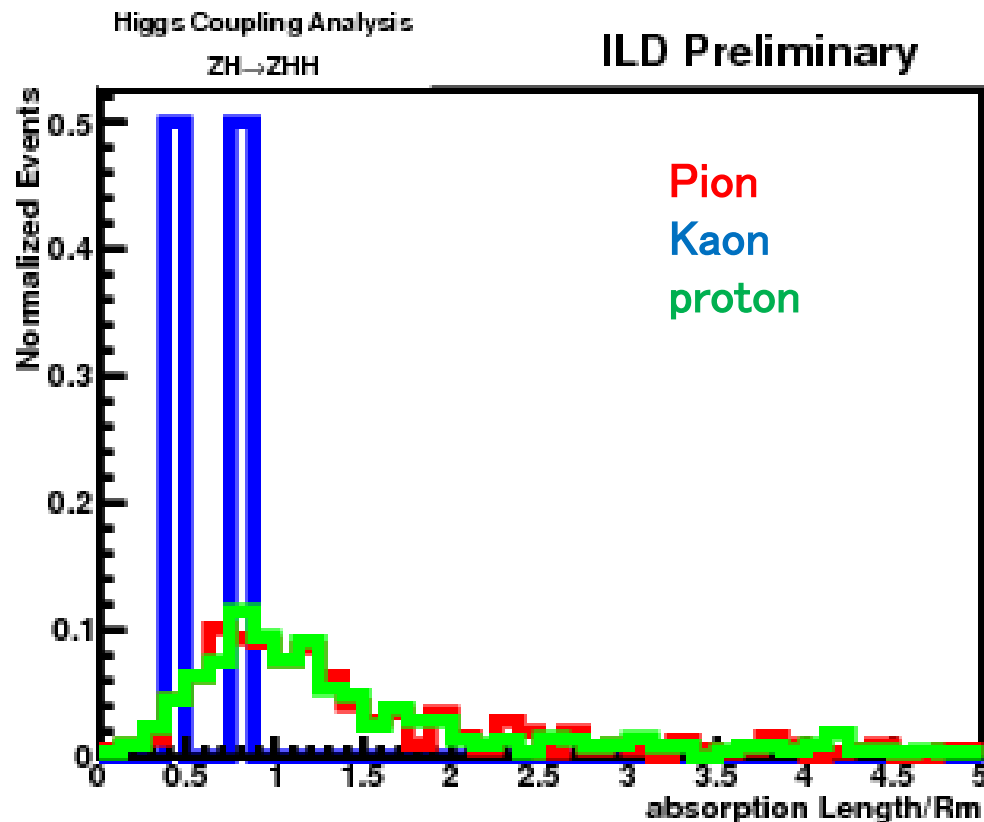
○ Longitudinal information

- Characterized with showerMax and xl20
- Low energy tracks $E < 20\text{GeV}$
- showerMax is scaled using Exp. shower max
- Each particle type (π , K, p)



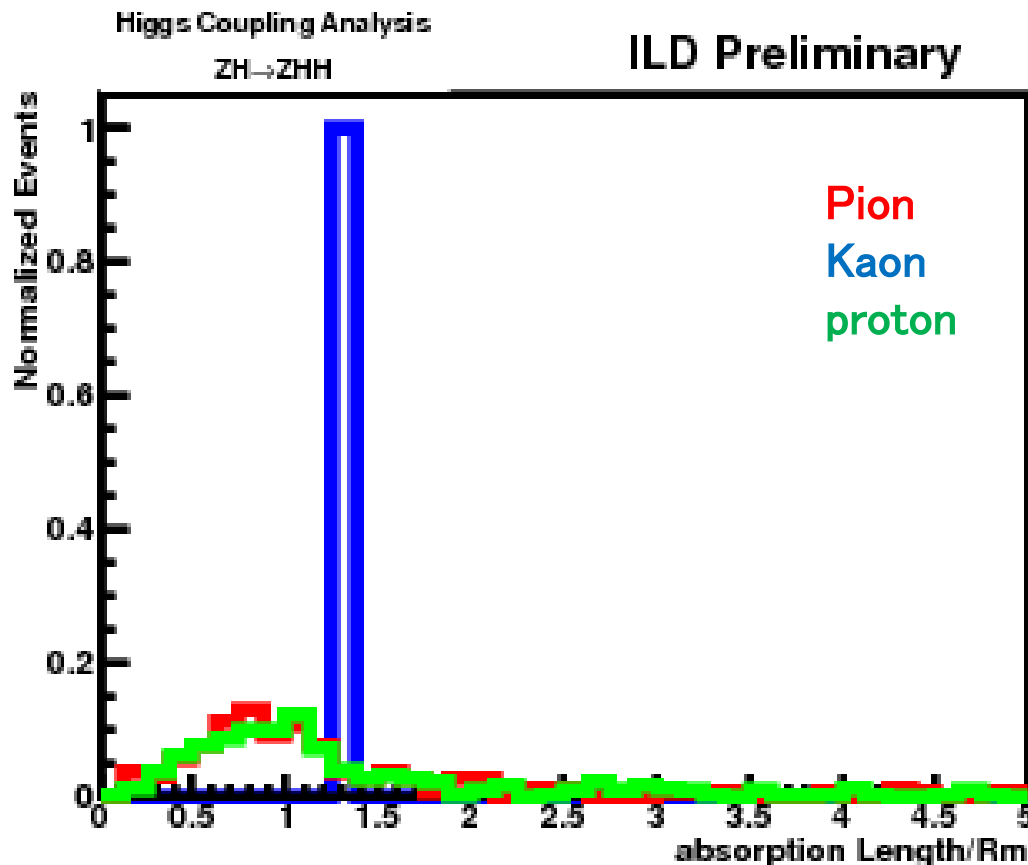
TRANSVERSE INFORMATION

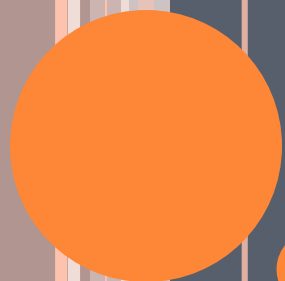
- Characterized with absorption length
- Low energy tracks $E < 20\text{GeV}$
- Each particle type (π , K , p)
- After correction



TRANSVERSE INFORMATION

- Characterized with absorption length
- middle energy tracks $20\text{GeV} < E < 40\text{GeV}$
- Each particle type (π , K, p)
- After correction





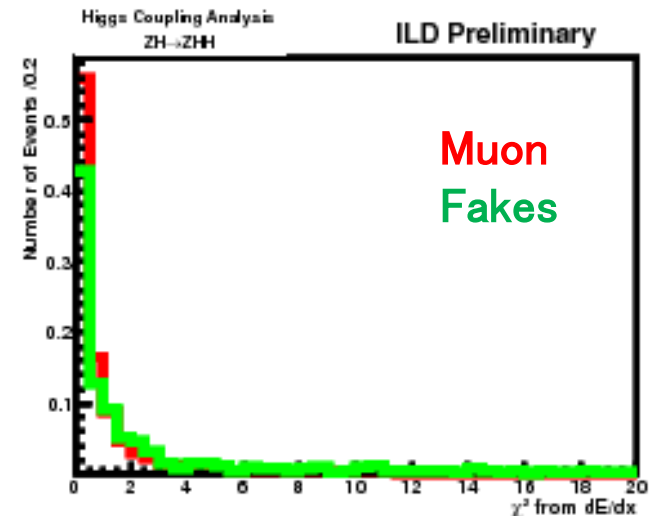
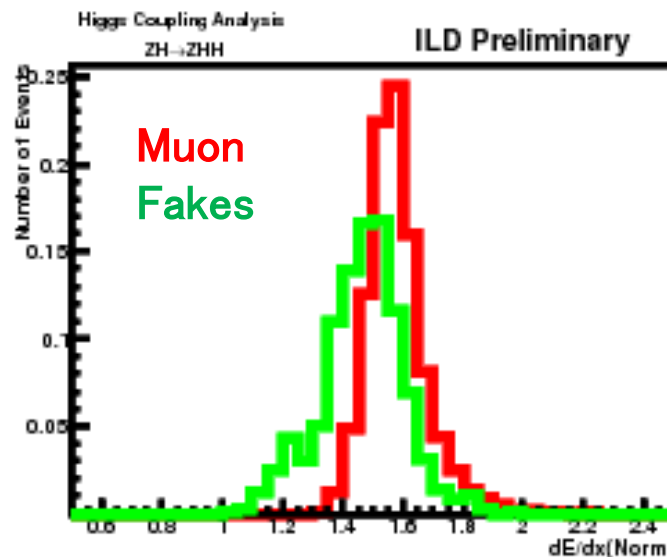
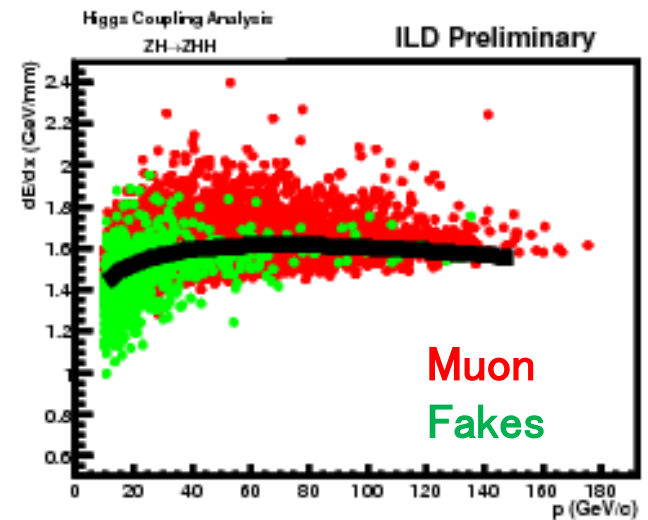
LEPTON ID

12

dE/dx STUDY FOR MUON TYPE

- Momentum dependence of dE/dx
 - Line: with muon hypothesis
 - Low momentum fakes look different
- dE/dx distribution
 - Difference is slight
- χ^2 distribution with muon hypothesis

- $\chi^2 = \left(\frac{\frac{dE}{dx} - \frac{dE}{dx}_{exp}}{\sigma} \right)^2$ 5% error imposed



BASIC IDEA

- Lepton ID using likelihood is introduced:
 - Lepton selection imposing just one cut
- Target is to find the leptons from W boson as Higgs daughter
 - In some case, lepton energy is so small
 - Form general lepton ID to make the analysis easier
 - Want to apply it to Z lepton finding too
- Likelihood definition:
 - Isolated lepton likeliness
$$L = \frac{s}{s+b} \quad s = \prod s_i \quad b = \prod b_i,$$

s_i :pdfs of signal variables b_i :pdfs of background variables
 - Weight factor is introduced to make the efficiency improved
taking log: $\log s = \sum w_i \log s_i$

PRELIMINARY RESULT

Comparison to old results

- Cut based, likelihood(old), likelihood(w shower profile & dE/dx)

Type	Cut based	Likelihood(old)	Likelihood(new)
Signal(%)	98.4	98.1	98.2
bbcsc(%)	7.9	3.1	2.6

- ~18% improvement
 - But, this is with $E(\text{lep}) > 15\text{GeV}$ to compare the results
 - It is necessary to loosen the energy(momentum) cut to gain the acceptance
- ## Its necessary to loosen the lepton energy cut
- $E > 10\text{GeV}$ or less than 10 GeV?
- ## Need optimization
- After optimization, start to the self coupling analysis

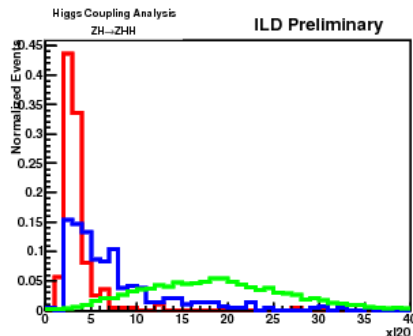
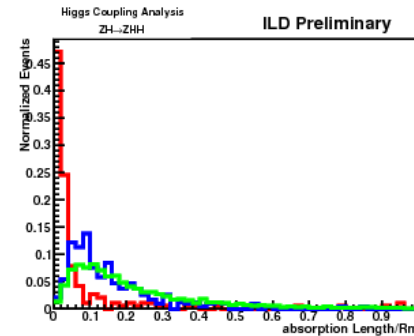
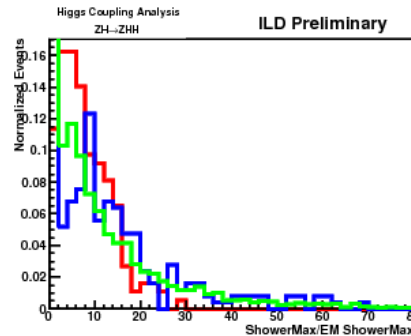
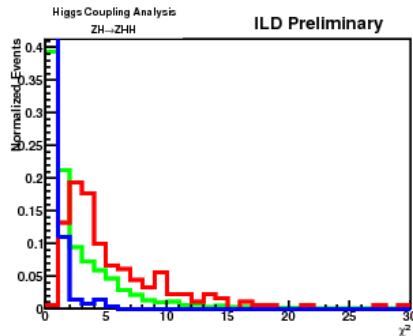
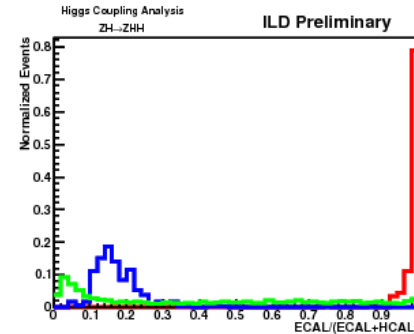
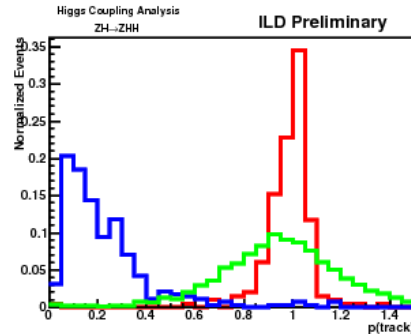
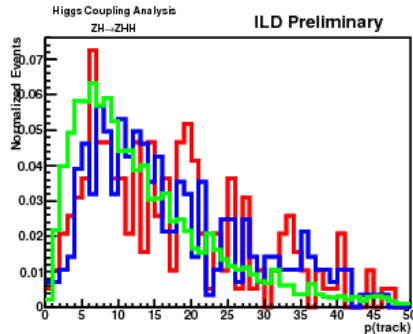


EXTRAS – FOR FUTURE PLAN

16

CHECK THE SECONDARY VERTEX

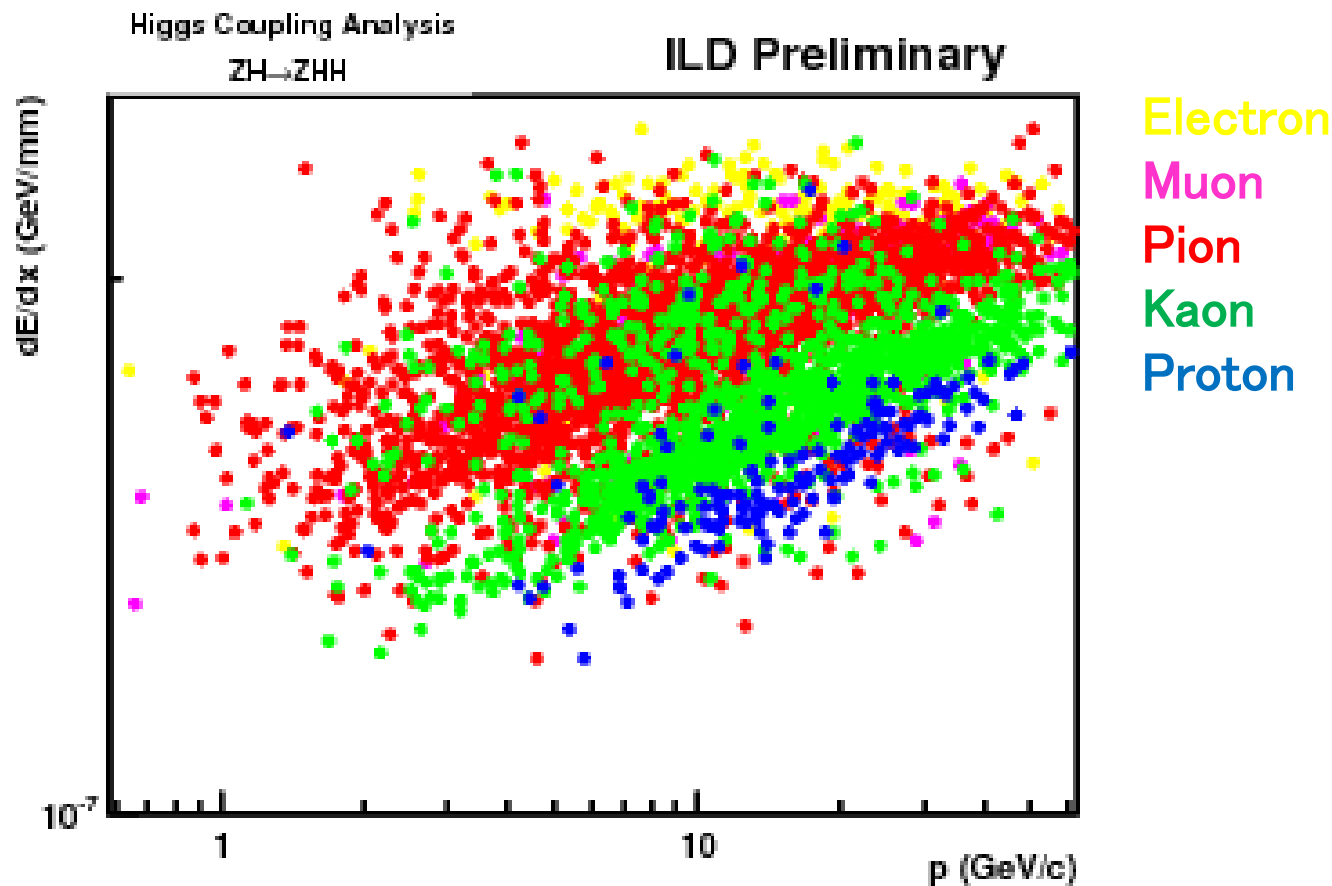
- Start to check the tracks coming from secondary(thirdary...) vertex
 - So far, all the secondary vertex is included

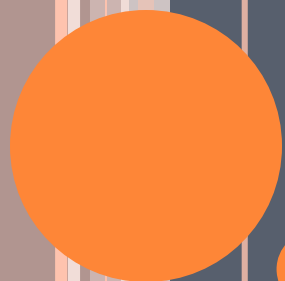


Electron
Muon
Hadrons

dE/dX

- Separation can be seen
 - Distribution is dirty...
 - It's hard to match to MC particles...





BACK UP



19

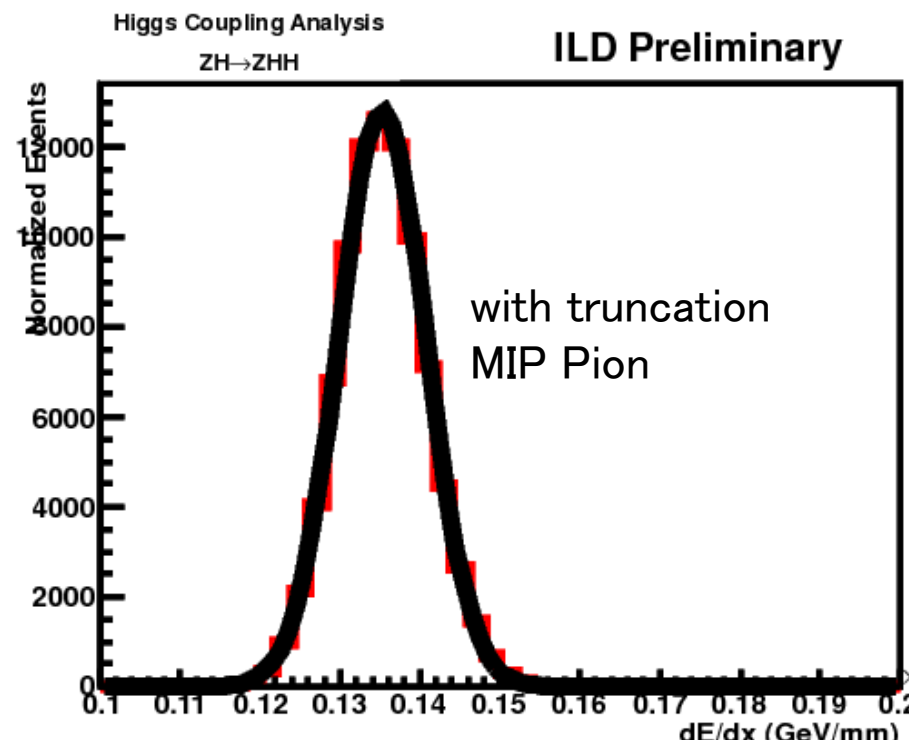
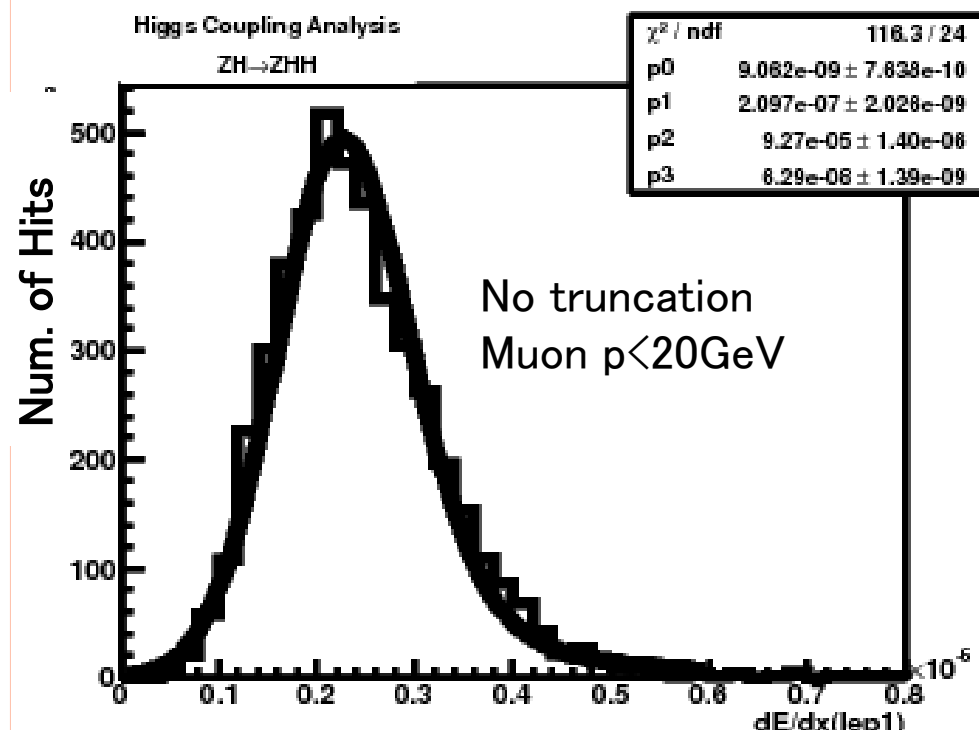


dE/dx

- For improvement, using dE/dx is one of the powerful tools
 - Particle ID for each track will give a large impact to the analysis
 - Application to general analysis component is very wide
 - Lepton ID
 - Track energy correction
 - B-tagging?
 - Jet clustering?
- Important factor to use dE/dx is: fluctuation
 - TDR: measurement resolution is **5%**
 - So, fluctuation from simulation is within 5% without detector effect
- dE/dx definition:
 - $\frac{dE}{dx} = \frac{\text{energy deposit}}{\text{flight path in the hit(TPC)}}$
 - dE/dx can be calculated at any hit point
 - Truncated mean is calculated as track dE/dx
$$\left\langle \frac{dE}{dx} \right\rangle = \frac{1}{n} \sum_i^n \frac{dE_i}{dx_i}$$
upper 30%, lower 8%(important!) hits are discarded to avoid Landau tail(next slide)
→ optimization is necessary

EFFECT OF LANDAU TAIL

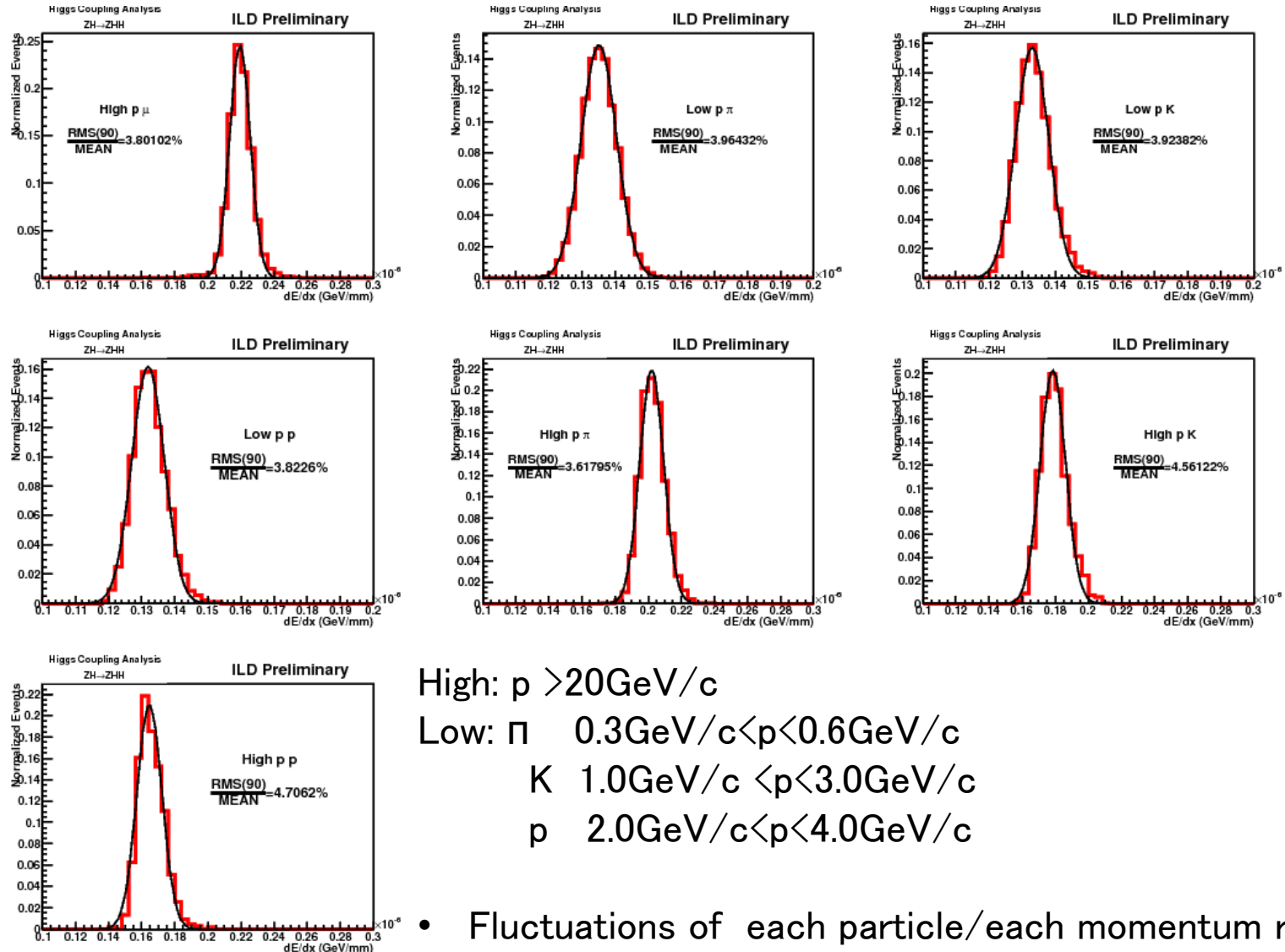
- Landau tail effect – muon tracks
 - dE/dx distribution of tracks
 - fitting – convolution of Gaussian and Landau
 - Tail can be seen in the case of no truncation
 - Agree with Astrid's study
- Truncated mean distribution – MIP pion($0.3\text{GeV}/c < p < 0.6\text{GeV}/c$)
 - Good Gaussian shape



dE/dX FLUCTUATION

○ Fluctuation of dE/dx using various type of tracks

● Estimation of RMS(90)/MEAN

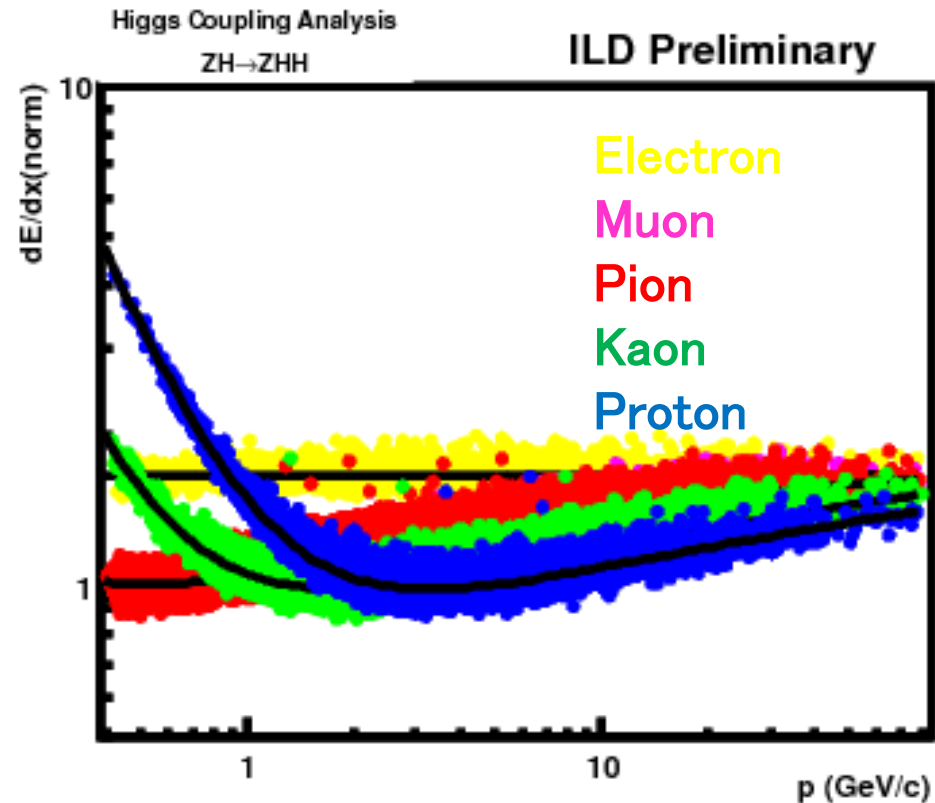
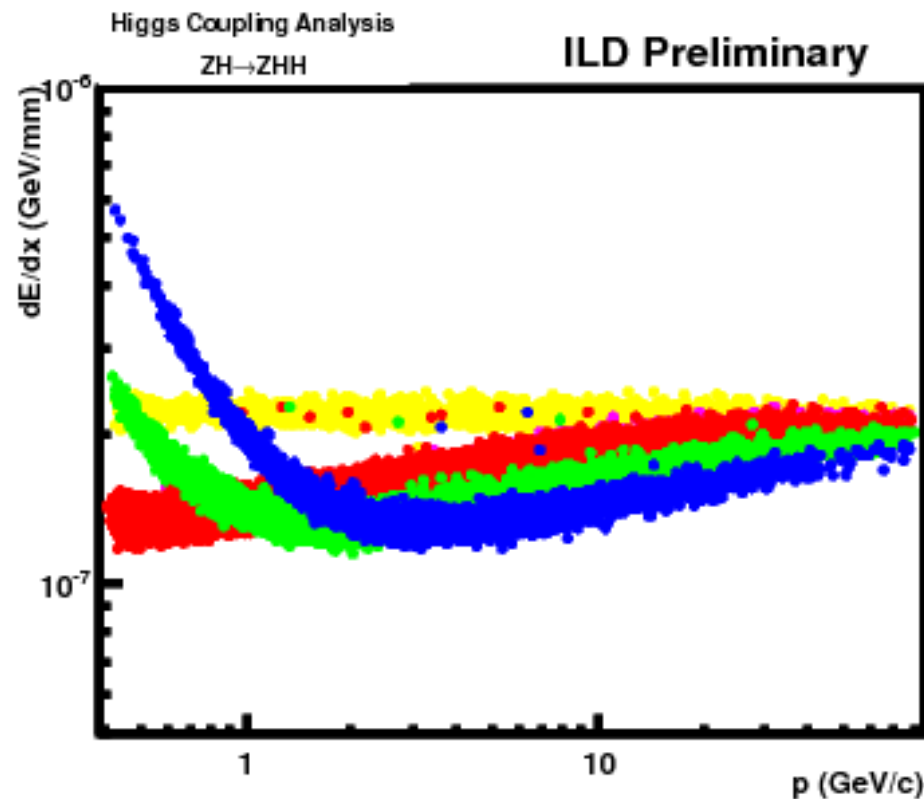


● Fluctuations of each particle/each momentum range

3 - (<5)%!!

dE/dX DISTRIBUTION

- For each particle
 - Polar angle dependence corrected
 - Num. of Hits dependence corrected
 - Scale to $\left\langle \frac{dE}{dx} \right\rangle = 1.0$ for MIP pion



SHOWER PROFILE

- Shower shapes in the calorimeter are different between electron/photon/muon/hadrons
 - So Characters of the clusters will be a good tool to distinguish tracks
 - Especially, electromagnetic shower shape is well known
 - Grabbing those information will boost leptonID efficiency/fake rejection efficiency

- Information extraction is based on the fitting:

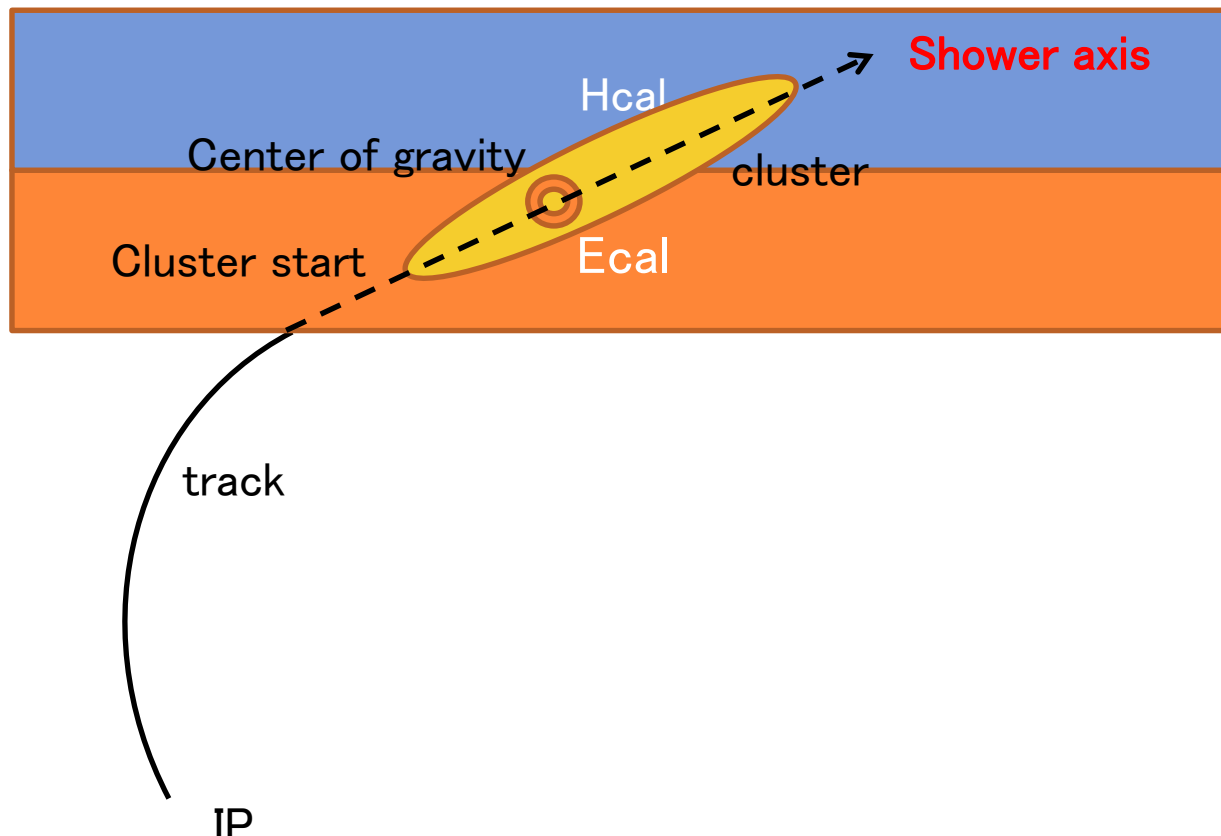
- Well-known EM shower profile

$$f(x_l, x_t) = ac \frac{(c(x - x_{l0}))^{b-1} \cdot \exp(-c(x - x_{l0})) \cdot \exp(-dx_t)}{\Gamma(b)}$$

- In addition, hit based variable is introduced to identify shower start
 - XI20 – length from cluster start to 20% of total energy deposit

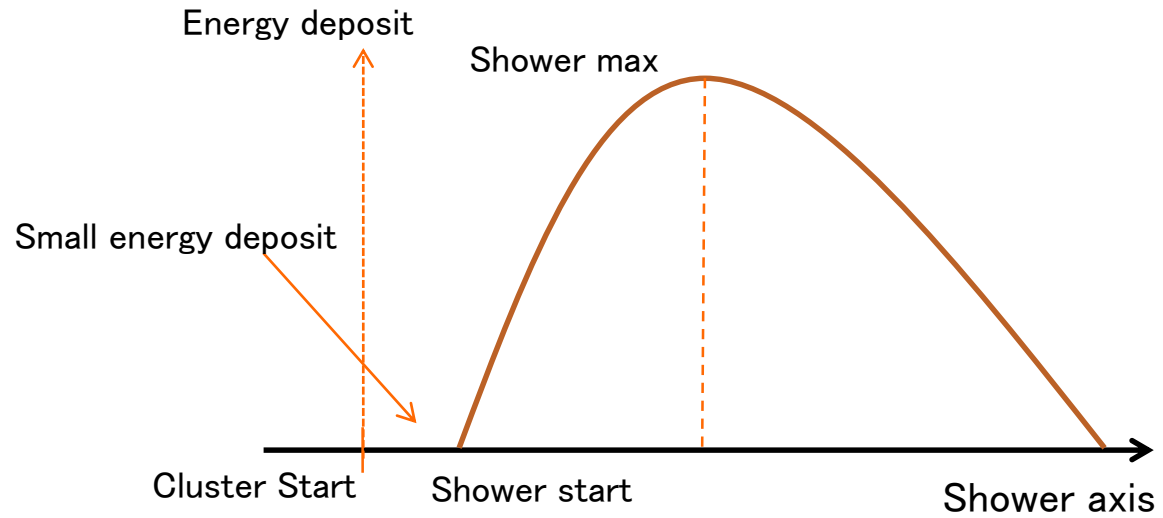
DEFINITION OF THE SHOWER AXIS

- Shower axis is the direction of the track intruding into calorimeter
 - This correction will change the shower start distribution from last talk
- All the hit points(x,y,z) are converted to longitudinal and transverse components along to the shower axis



SHOWER PROFILE

longitudinal



transverse

