Higgs Recoil Mass

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Analysis Conditions

- Target: higgs mass measurement using recoil mass against Z decaying to μμ with DBD sample, mH=125GeV.
- Looking currently μμ channel only
  (ee channel will be done)
- P(e+,e-) = (+0.3, -0.8), L = 250 fb-1
- The almost same selections as LoI analysis* are used

- * HZ Recoil Mass and Cross Section Analysis at ILD

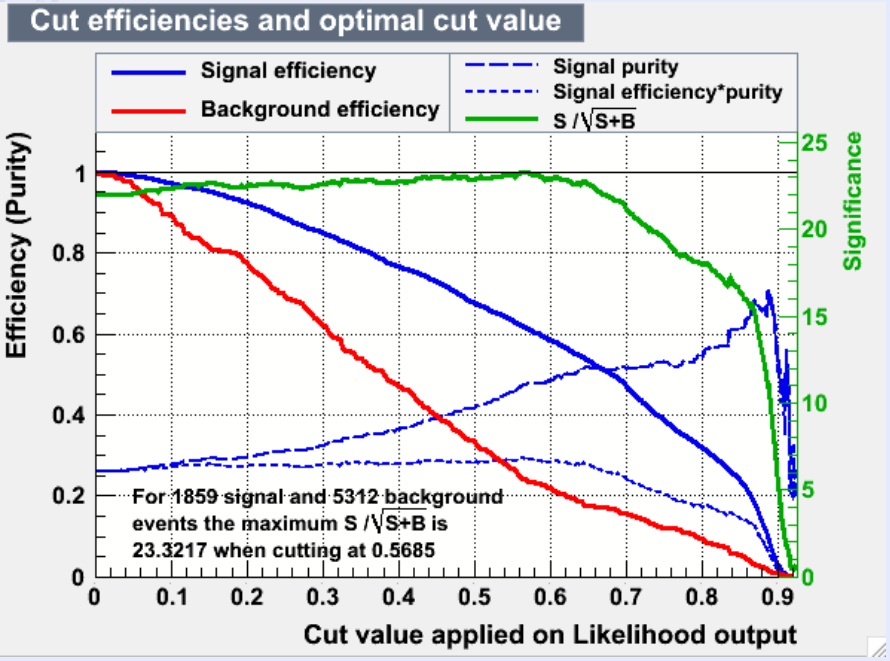
Background and Selection

- Main background: di-muons from
  1. e^+e^- -> WW, ZZ -> μμνν, μμff
  2. e^+e^- -> Z -> μμ, with large ISR/FSR
- Muon identification
  1. $p > 15$ GeV
  2. $E_{ecal} / E_{total} < 0.5$
  3. $E_{total} / P_{track} < 0.3$
- good track selection
  1. $\delta P/P^2 < 2.5 \times 10^{-5} + 8 \times 10^{-4} / p$ [GeV/c] for $|\cos\theta_{pfo}| < 0.78$
  1. $\delta P/P^2 < 5 \times 10^{-4}$ for $|\cos\theta_{pfo}| > 0.78$

Cuts

- Cuts
- Transverse Momentum of di-lepton system $p_{Tdl} > 20$ GeV
- Invariant mass $80 < M_{dl} < 100$ GeV
- Acoplanarity (= $|\varphi_{l+} - \varphi_{l-}|$) $0.2 < acop < 3.0$ [rad]
- For high energy photon radiation from final state muon, $\delta p_{Tbal} = p_{Tdl} - p_{T\gamma} > 10$ GeV
- In PFOs, $|\cos\theta_{missing}| < 0.99$
- Recoil mass $115 < M_{recoil} < 150$ GeV
- Likelihood cut $f_L > 0.4$ by TMVA package. Input variables are
  1. Acollinearity, $acol = \cos^{-1}(\mathbf{P}_{l+} \cdot \mathbf{P}_{l-} / |\mathbf{P}_{l+}||\mathbf{P}_{l-}|)$
  2. di-lepton angle respected for beam axis, $\cos\theta_{dl}$
  3. p_{Tdl}
  4. M_{dl}

Likelihood Cut

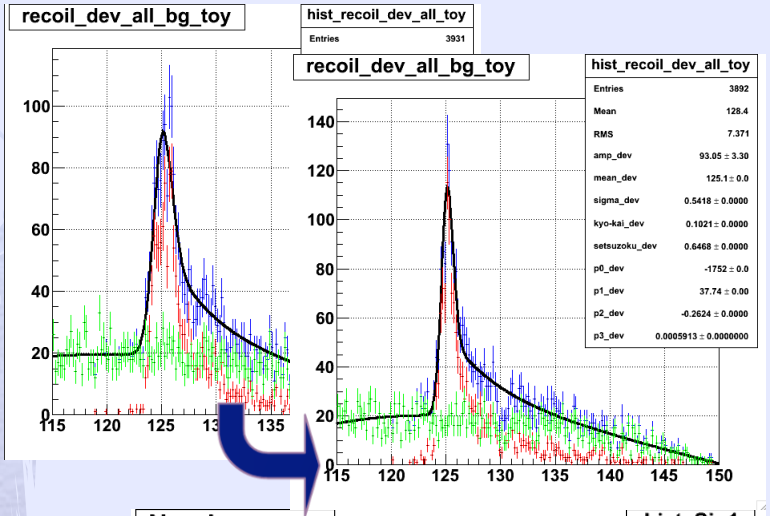


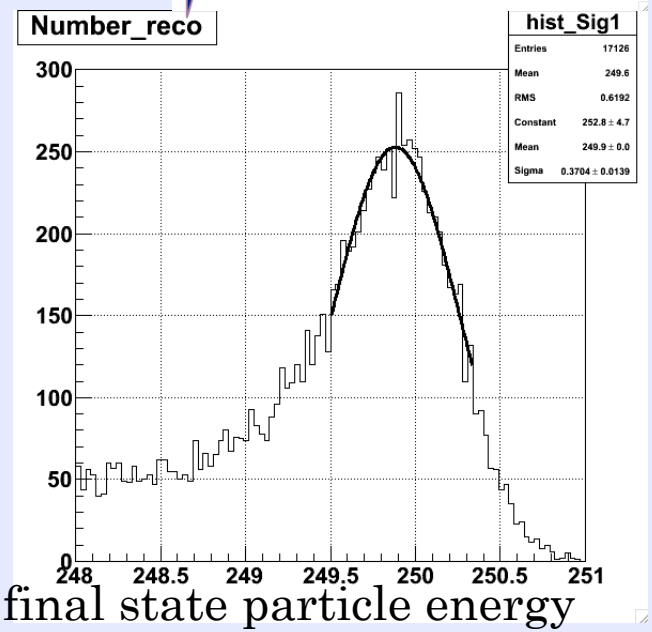
- It seems to be optimal to select $f_L > 0.5$, however, in order to remain large signal events as possible, I set likelihood cut value $f_L > 0.4$.

Cut Table

	signal		background	
no cut	2603		3.7M	
good μ	2411	92.59%	1.4M	37.45%
p_{Tdl}	2252	86.49%	250927	6.75%
M_{dl}	2077	79.79%	129695	3.49%
acoplanarity	1941	74.54%	118103	3.18%
δP_{Tbal}	1893	72.71%	33961	0.91%
$\lvert\cos\theta_{missing}\rvert$	1882	72.27%	33094	0.89%
M_{recoil}	1859	71.39%	5312	0.14%
likelihood	1453	55.82%	2265	0.06%

Calculation of Recoil Mass





final state particle energy from MC Information [GeV]

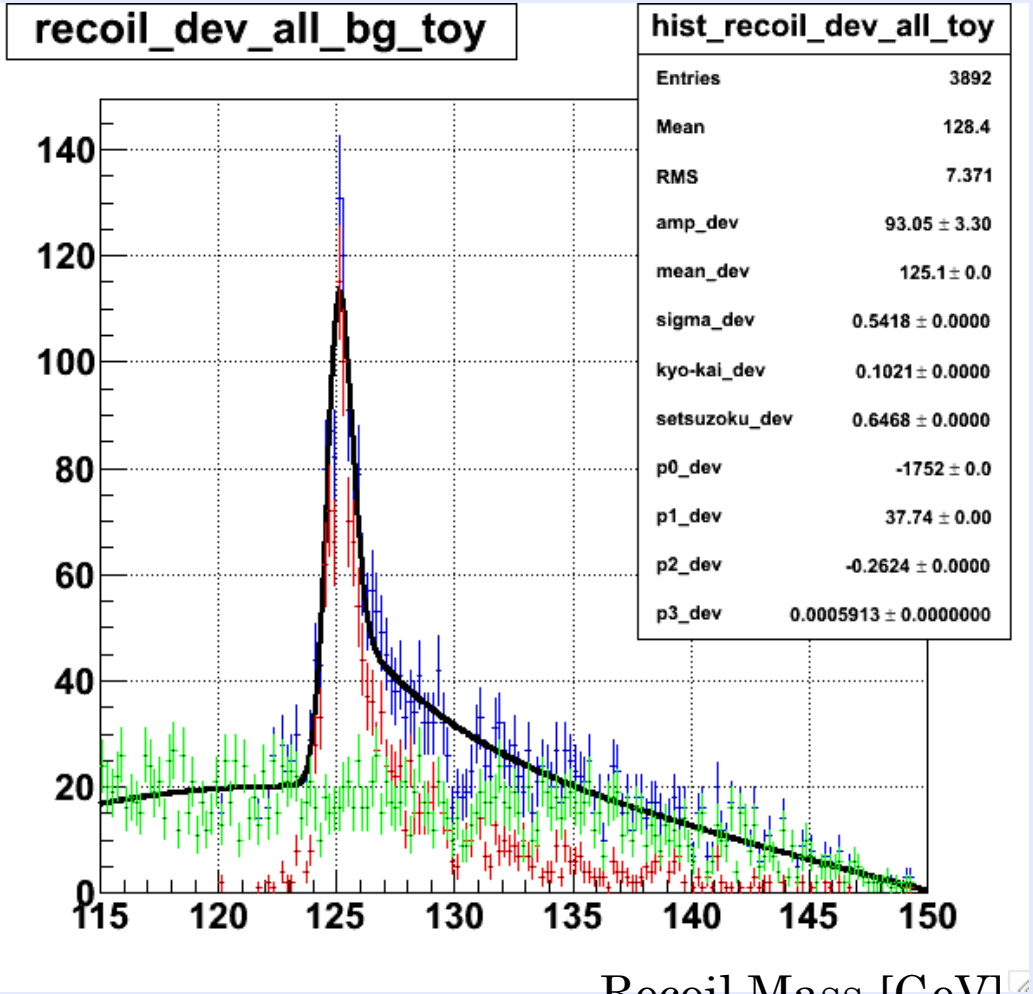
- I calculated higgs recoil mass taking crossing angle effect into account.
- E_{CM} = 249.89 [GeV] is used instead of 250. This modification leads the shift of the recoil mass distribution by ~ 100 [MeV].

Fitting the recoil mass

- Using recoil mass distribution (bin width: 200 MeV)
- Background is fitted with 3rd polynomial
- Using signal (~ 1 ab^{-1})+ fitted background distribution, the 1st fit is performed with GPET* + background (fixed) function
- Toy-MC with Poisson distribution in each bin performed
  - Background: generated from fitted function (because MC statistics is poor)
  - Signal: generated from full-MC result
- 2nd fit is performed for each toy-MC sample using GPET + background with all parameters but Gaussian mean and height are fixed to the result of the 1st fit

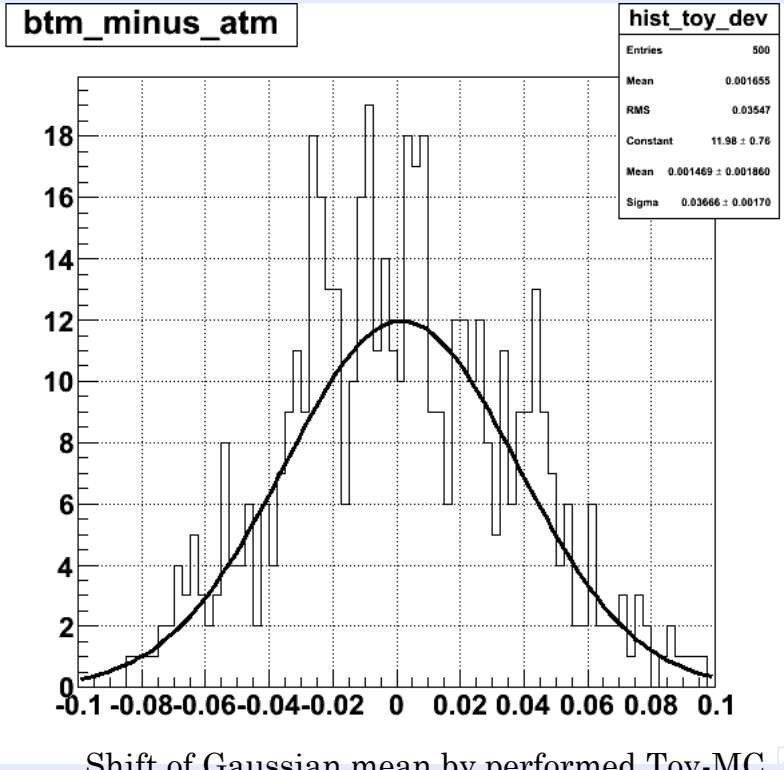
*GPET: Gaussian Peak with Exponential Tail (5 parameters)
left part: Gaussian, right part: adding Gaussian and exponential, free parameters: height, mH, Gaussian width, position to connect left and right part of the function (in deviation from the Gaussian center), ratio between Gaussian and exponential in right part

Fit Result

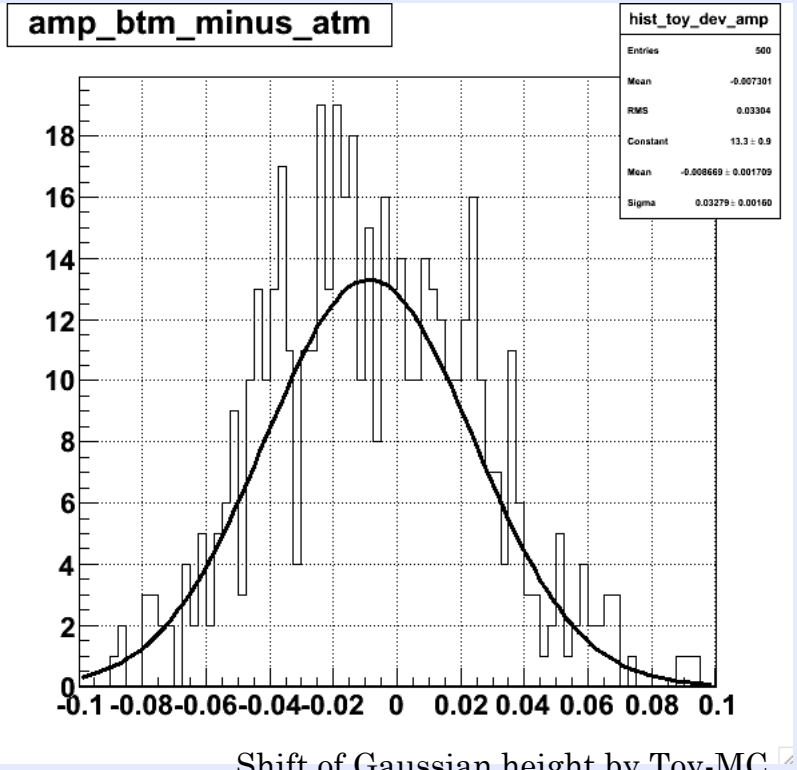


- The result of fitting by two free parameters, height and Gaussian mean.
- Red plot is signal toy MC, green is BG toy MC, and blue is sum of them.

Mean and Height



Shift of Gaussian mean by performed Toy-MC



Shift of Gaussian height by Toy-MC

- Fitted mass and signal height with 500 toy-MC samples
  Resolution of Gaussian mean : 34 MeV
  Resolution of Signal height (arbitrary unit) : 3.4 %
- No correlation between mean and height is seen.

Notes

- The Higgs mass resolution (34 MeV) is consistent with LoI (37 MeV)
- Fitted mean slightly deviates from the true Higgs mass (δm = 67 MeV, ~2σ), but it can be corrected with MC. Fit method will also be refined (by including beam effect etc.).
- Need study of systematic uncertainties such as the beam spectrum (including CM frame reconstruction), momentum scale.
- The same analysis for eeX channel will be done.