Higgs Recoil Mass Study at 350 GeV

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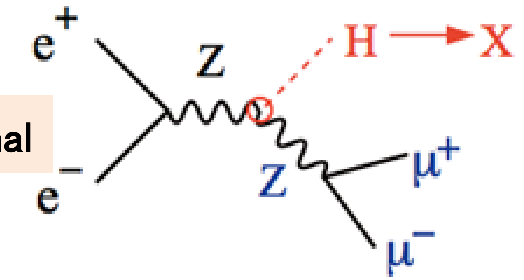
recoil mass study using e+e- → ZH → μ+μ-H
Ec.m.s. = 350 GeV, L = 333 fb-1
And also Ec.m.s. = 250 GeV, L = 250 fb-1

signal



$$M_X^2 = \left(p_{CM} - (p_{\mu^+} + p_{\mu^-})\right)^2$$

Pe2e2h_.eL.pR & Pe2e2h._eR.pL

Goal:

precise measurement of

Higgs cross section σ_H

BG :
included all 2f, 4f, 6f BG processes

Layout of this Talk

- Evaluation of data selection performance
  cross section error, efficiency, significance, S/N ratio, ect……
- Compare alternative polarization scenarios
- Comparison with sqrt(s)=250 GeV
- Summary & Plans

Data Selection Method and Fitting Method for Recoil Mass Plot

Muon Selection

- reject neutrals
- Ptot > 5 GeV
- small E_cluster / P_total < 0.5
- **Best track selection** : cos(track angle) < 0.98 & |D0/δD0| < 5

Data Selection Method

Experimented with various cut threshold to achieve highest sig eff and S/N raio

Best Z Candidate Selection

2 muon candidates with **opposite charge**

choose pair **with invariant mass closest to Z mass**

Definitions

- M_inv : invariant mass of 2 muons
- pT_mumu : pT of reconstructed muons
- pTγ_max : pT of most energetic photon
- θ_Zpro = Z production angle

Final Selection for sqrt(s)= 350 GeV

- 84 GeV < M_inv < 98 GeV
- 10 GeV < pT_mumu < 140 GeV
- dptbal = |pT_mumu – pTγ_max| > 10 GeV
- coplanarity < 3
- |cos(θ_Zpro)| < 0.91
  (Z production angle)
- 120 GeV < Mrecoil < 140 GeV

for sqrt(s)=250 GeV, no coplanrity cut

Results after selection (sqrt(s)=350 GeV)

- Sig efficiency = 48.9 +/- 0.5%
- S/N = 0.40, significance = 17.2
- # of signals = 1092+/−55

after all cuts, dominant BG are:

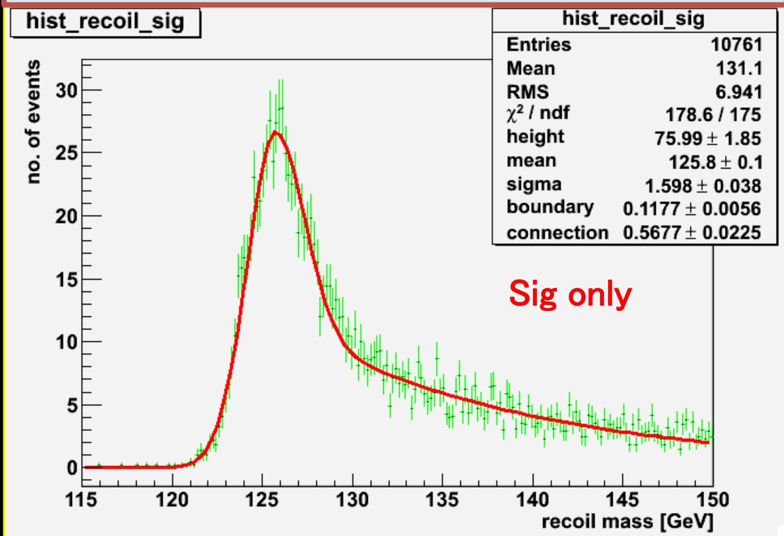
sqrt(s) = 350 GeV : #1) 4f_ZZ_sl #2) 2f_Z_l #3) 4f_WW_sl, no ttbar BG left

sqrt(s) = 250 GeV : #1) 2f_Z_l #2) 4f_ZZ_sl #3) 4f_ZZWWMix_l

fitting for recoil mass histogram

1st time fitting:

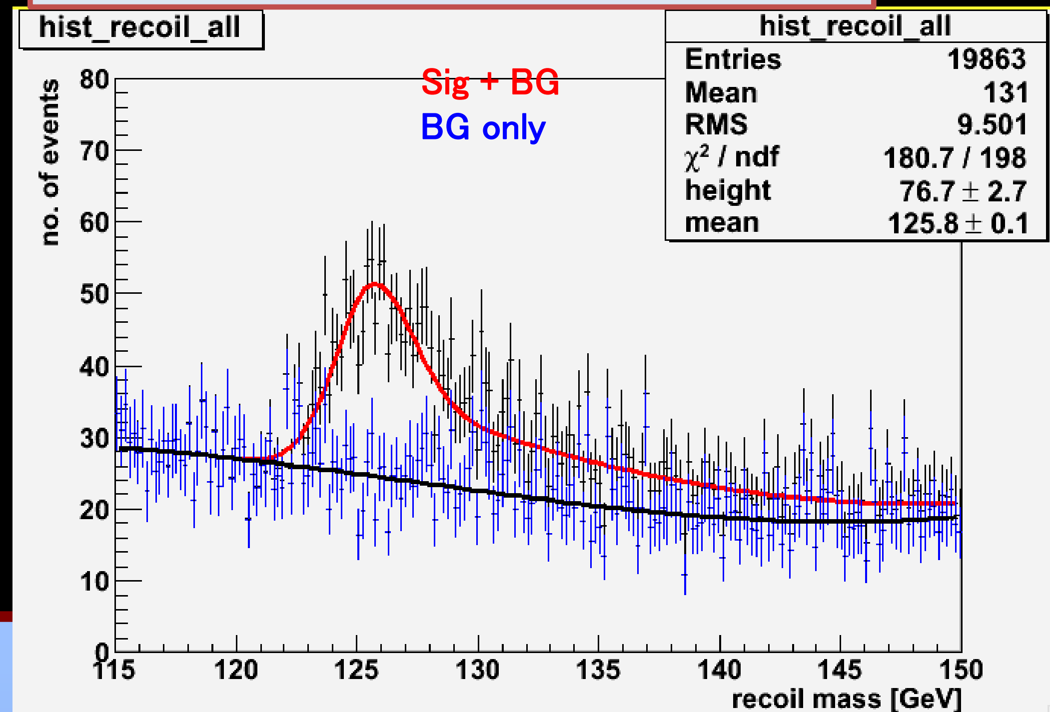
- fit only signal : float all 5 GPET pars
- fit BG only 3rd order polynomial



Final fitting:

float only height and mean,

Fix BG function and remaining GPET pars from 1st time fitting



◆ **SIGNAL: GPET:** 5 parameters :

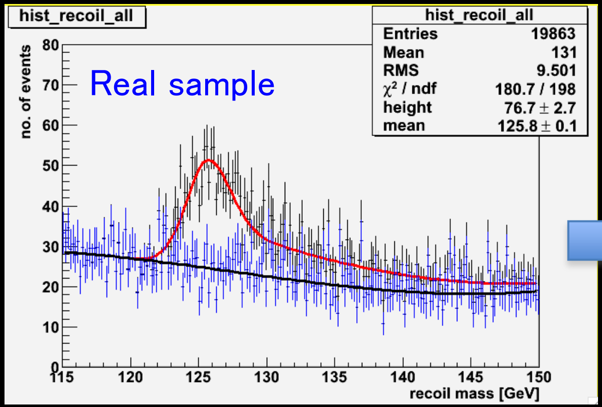
Gaus (left-side) , Gaus + expo (right side)

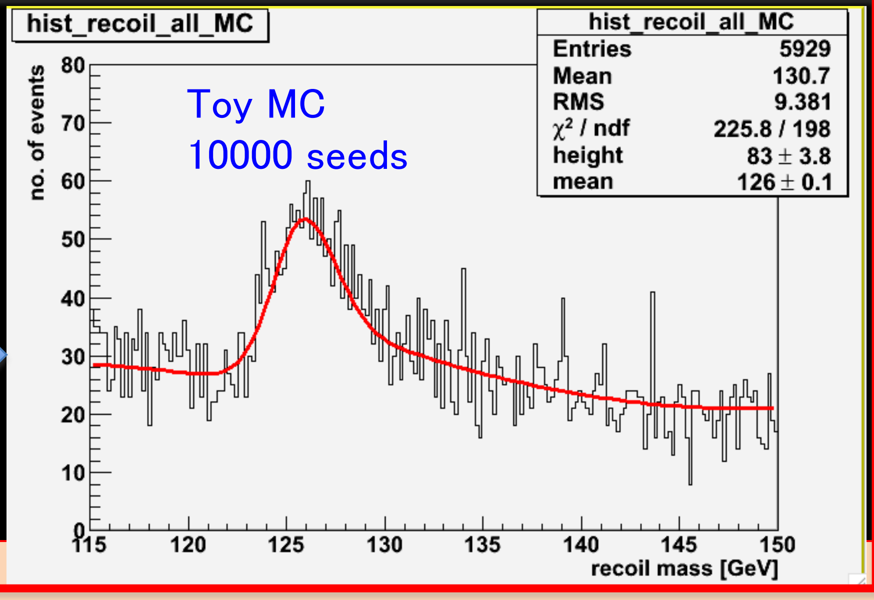
$$\frac{N}{\sqrt{\pi\sigma}}\exp\left\{-\frac{1}{2}\left(\frac{x-x_{mean}}{\sigma}\right)^2\right\} \qquad \left(\frac{x-x_{mean}}{\sigma}\le k\right)$$

$$\frac{N}{\sqrt{\pi\sigma}}\left[b\cdot\exp\left\{-\frac{1}{2}\left(\frac{x-x_{mean}}{\sigma}\right)^2\right\}+(1-b)\exp\left\{-k\left(\frac{x-x_{mean}}{\sigma}\right)\right\}\exp\left(k^2/2\right)\right] \qquad \left(\frac{x-x_{mean}}{\sigma}\ge k\right)$$

Toy MC Studies to evaluate quality of fitting and precision for cross section and No. of signals

Toy MC Studies





Goal:

- **test validity of fitting** : **Pull plot** for xsec = [(fitted xsec)−("real" xsec)]/ (xsec fitting error)
- **Evaluated precision of xsec and number of signals (Nsig)**

Method:

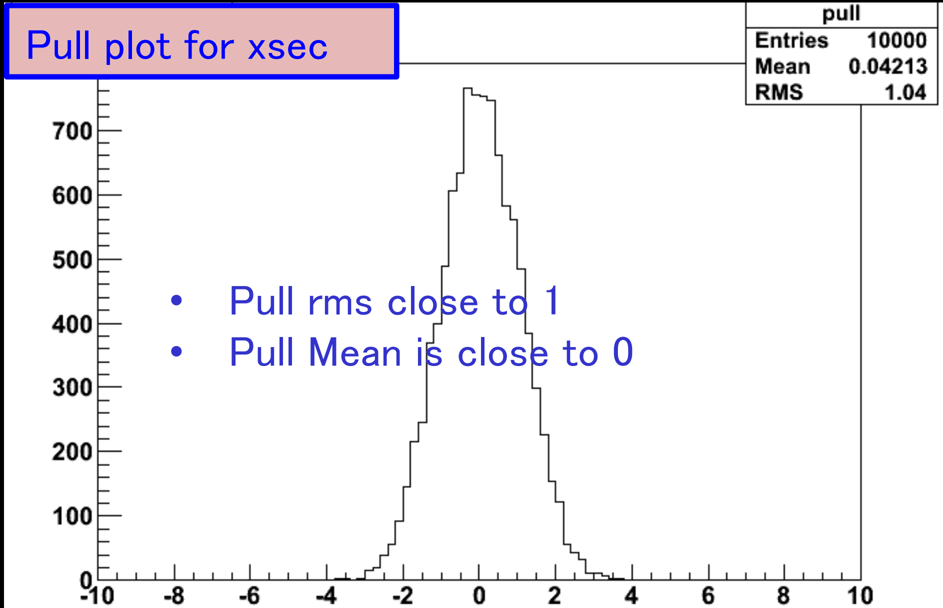
- Generate MC according to fitted function (GPET + BG) for real sample
- Input #of events according to Poisson distr (mean = real # of input)
- Fit MC histogram with same function
- Integrate under GPET to get Nsig → calculate xsec

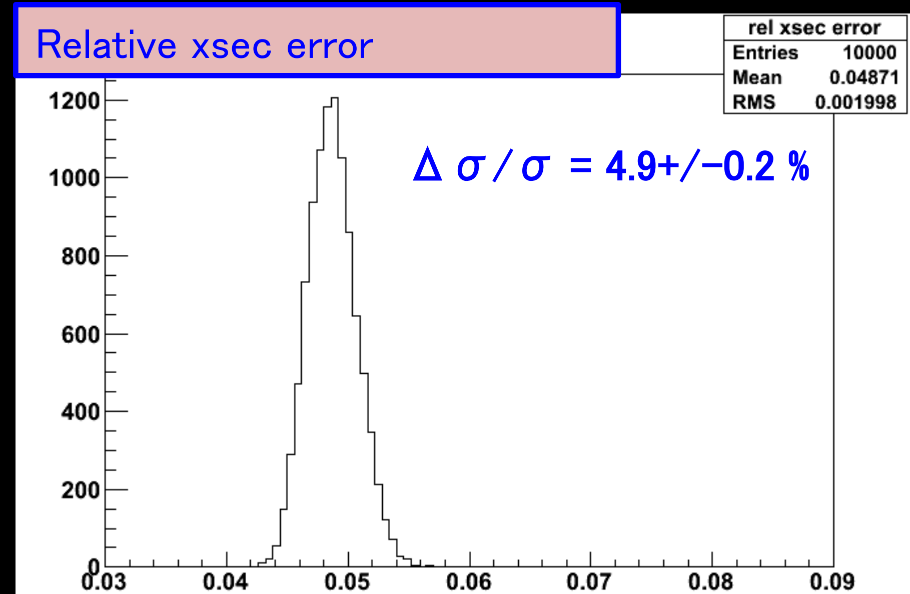
Results:

Pull plot seems reasonable

Nsig and xsec consistent with "real values from sample" within rms error ranges

example of results on next page



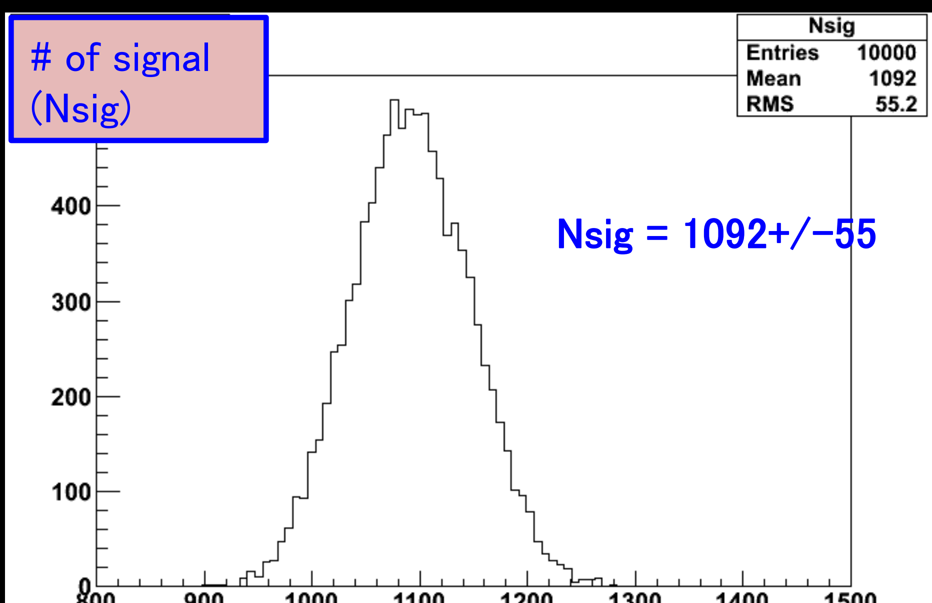


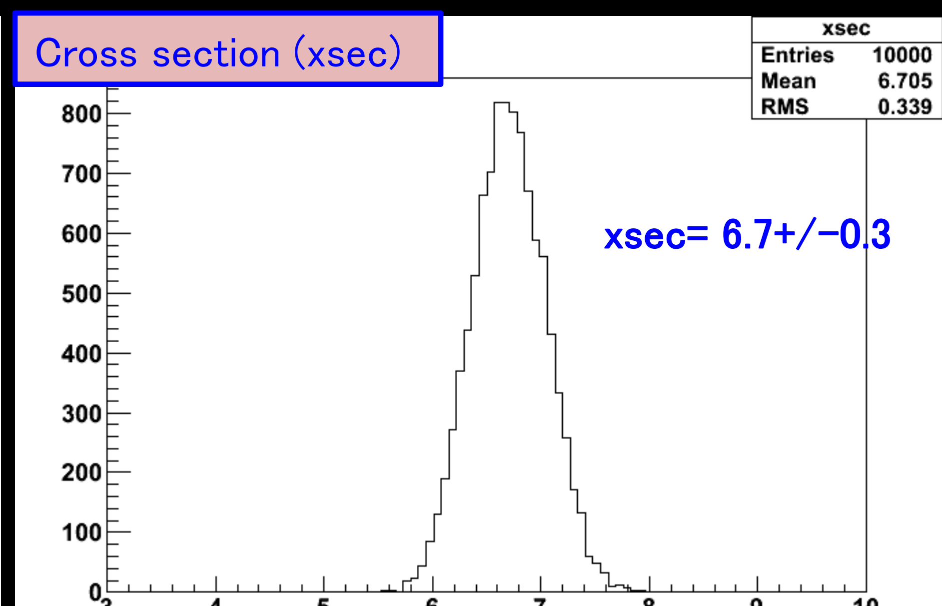
Result of Toy MC 10000 seeds

sqrt(s)=350 GeV

- “real xsec = 6.688” , “ real Nsig = 1088”

Consistent within error ranges





Compare Results between Alternative Polarization Scenarios

(−0.8, +0.3)　vs　(+0.8, −0.3)

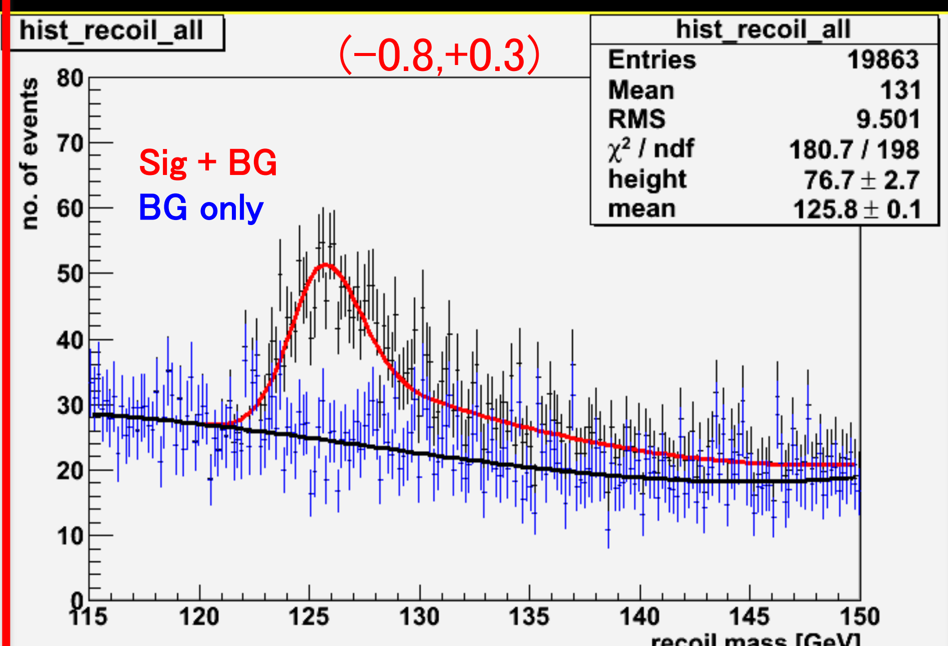
sqrt(s) = 350 GeV

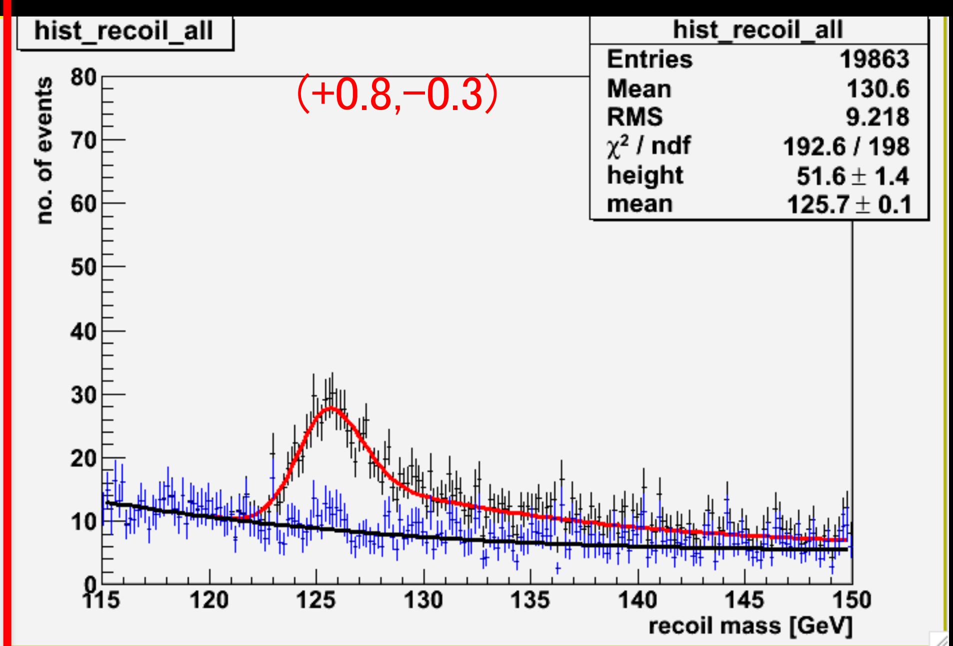
L = 333 fb-1

results for sqrt(s) =350 GeV , L = 333 fb-1

evaluated using Toy MC generated from these fitted function shapes

350 GeV	ε	Δσ/σ	xsec	Nsig	S/N	significance
(−0.8,+0.3)	48.9+/−0.5%	4.9+/−0.2%	6.71+/−0.34	1092+/−55	0.4	17.7
(+0.8,−0.3)	47.8+/−0.5%	5.0+/−0.2%	4.53+/−0.26	720+/−41	0.75	17.8





Compare with results for

sqrt(s) = 250 GeV

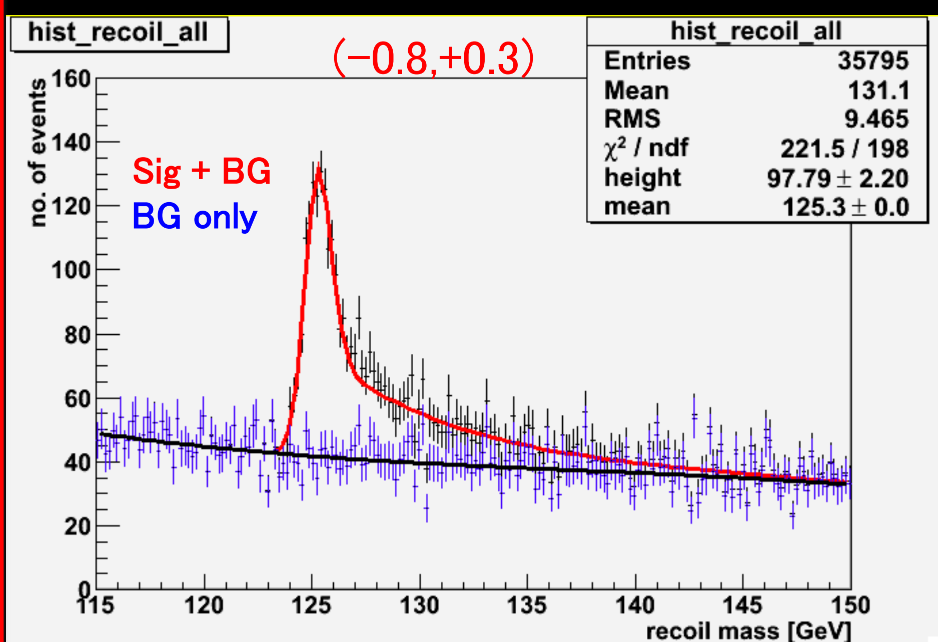
L = 250 fb-1

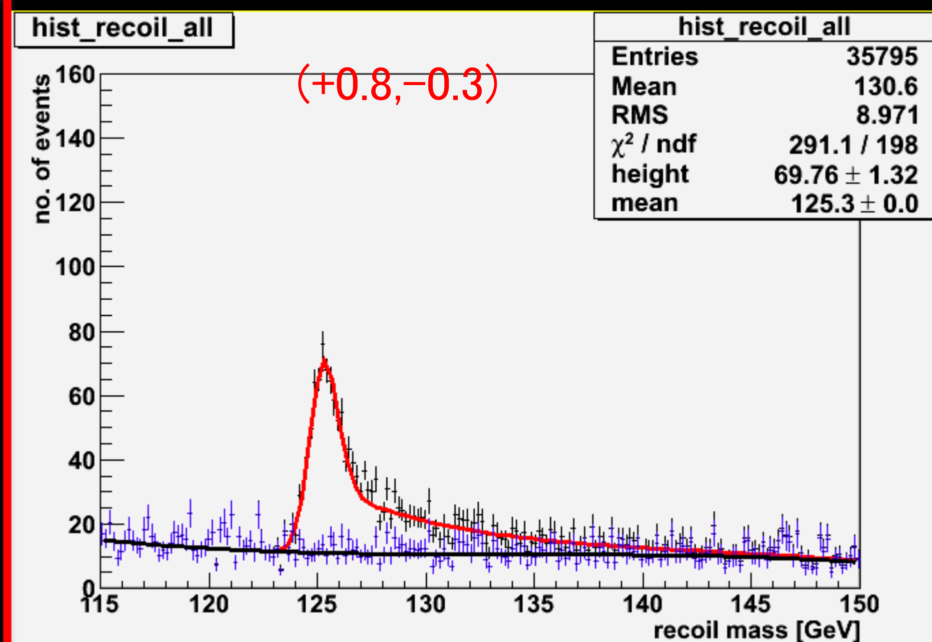
Also compare alternative polarization scenarios

results for sqrt(s) =250 GeV , L = 250 fb-1

evaluated using Toy MC generated from these fitted function shapes

250 GeV	ε	Δσ/σ	xsec	Nsig	S/N	significance
(−0.8,+0.3)	66.4+/−0.5%	3.6+/−0.1%	10.52+/−0.38	1747+/−64	0.37	21.7
(+0.8,−0.3)	64.4+/−0.5%	3.3+/−0.1%	8.68+/−0.30	1398+/−48	0.81	22.7





Compare sqrt(s) =350 GeV and sqrt(s)= 250 GeV , polarization (−0.8,+0.3) and (+0.8, −0.3)

Evaluated xsec error and validity of fitting using Toy MC generated from these fitted function shapes

	ε	$\Delta\sigma/\sigma$	xsec	Nsig	S/N	significance
350 GeV						
(−0.8,+0.3)	48.9+/−0.5%	4.9+/−0.2%	6.71+/−0.34	1092+/−55	0.4	17.7
(+0.8,−0.3)	47.8+/−0.5%	5.0+/−0.2%	4.53+/−0.26	720+/−41	0.75	17.8
250 GeV						
(−0.8,+0.3)	66.4+/−0.5%	3.6+/−0.1%	10.52+/−0.38	1747+/−64	0.37	21.7
(+0.8,−0.3)	64.4+/−0.5%	3.3+/−0.1%	8.68+/−0.30	1398+/−48	0.81	22.7

$\Delta\sigma/\sigma$ almost no difference between 2 polarization scenarios

◆for (+0.8, −0.3) : S/N much higher:

- WW BGs significantly suppressed (< 1/10 of (−0.8, *0.3)), other major BGs less also
- however statistics is lower

Summary

- Higgs recoil study using **e+e- → ZH → μ+μ-**H @ **Ec.m.s =350 GeV,** L = 333 fb-1

- **optimization of data selection method**
- compared with @ **Ec.m.s. = 250 GeV, L = 250 fb-1**
- **Compared different polarization scenarios : (-0.8, 0.3) vs (+ 0.8, -0.3)**

< Preliminary results >

350 GeV:

(-0.8, +0.3) **Δσ / σ = 4.9 +/-0.2 % , ε_sig = 48.9 +/- 0.5 %,** S/B ~ 0.40

(+0.8, -0.3) **Δσ / σ = 5.0 +/-0.2 % , ε_sig = 47.8 +/- 0.5 %,** S/B ~ 0.75,

250 GeV:

(-0.8, +0.3) **Δσ / σ = 3.6 +/-0.1 % , ε_sig = 66.4 +/- 0.5 %,** S/B ~ 0.37

(+0.8, -0.3) **Δσ / σ = 3.3 +/-0.1 % , ε_sig = 64.4 +/- 0.5 %,** S/B ~ 0.81

- sqrt(s)=250 GeV has better Δσ/σ and signal efficiency
- (+0.8, -0.3) has better S/N , but lower statistics, Δσ/ σ almost same as nominal

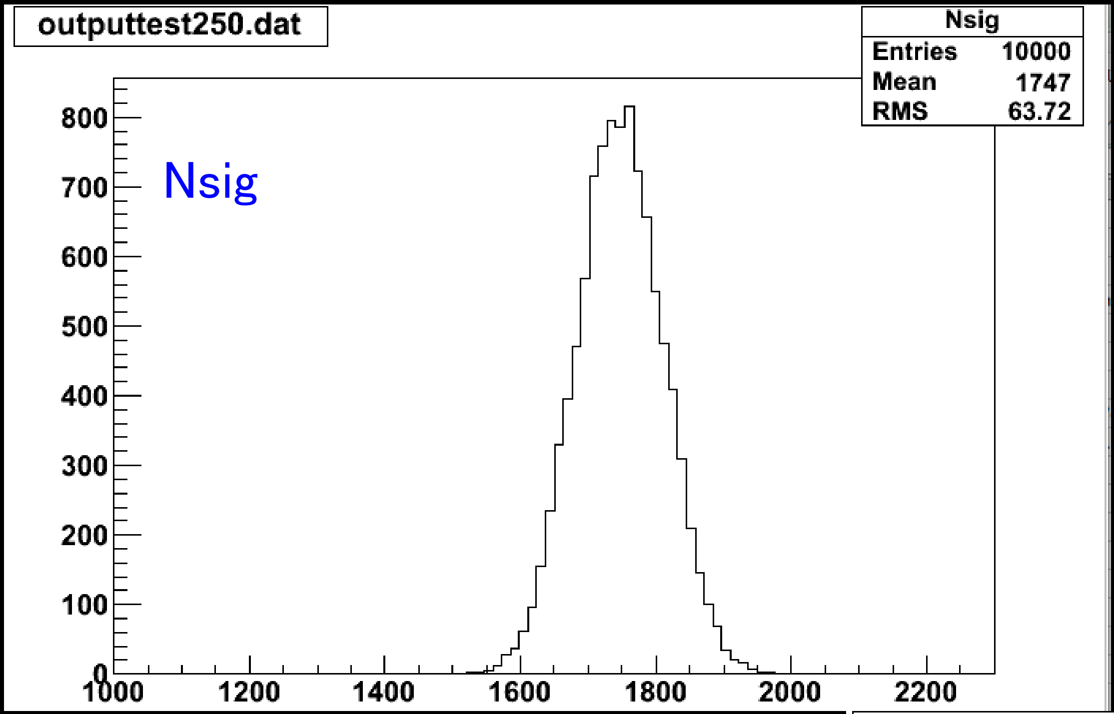
Plans

- **cut more BG without losing too much signal ?**
- ➢ **improve data selection :** Implement muon isolation and likelihood cut ?
- study **precision of fitted recoil mass M_H**
- study **alternative polarization scenarios** e.g. (-0.8, 0) (+0.8, 0) …ect…

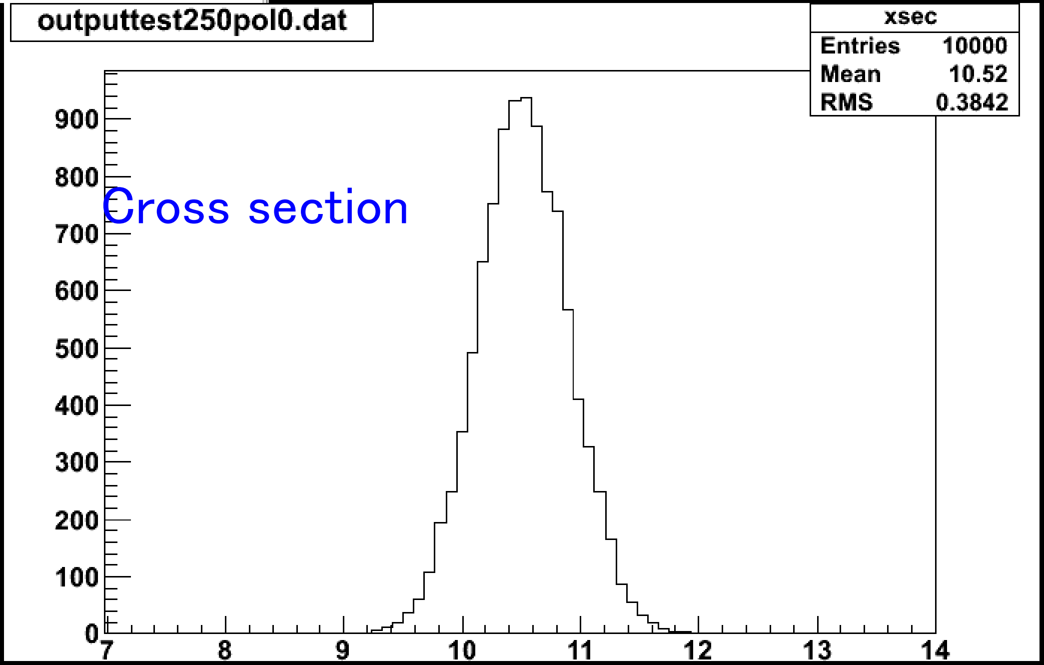
we should balance merits of physics and accelerator issues , esp for 250 GeV

BACKUP

250 GeV
Toy MC　10000 seeds



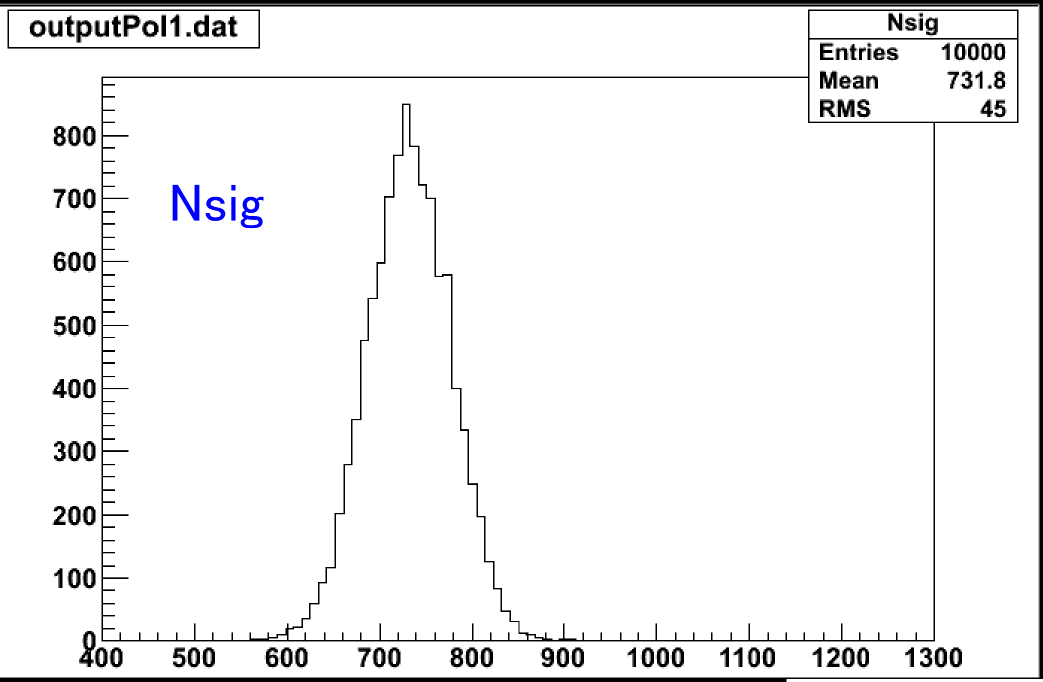
(−0.8,+0.3)



"real xsec = 10.42"

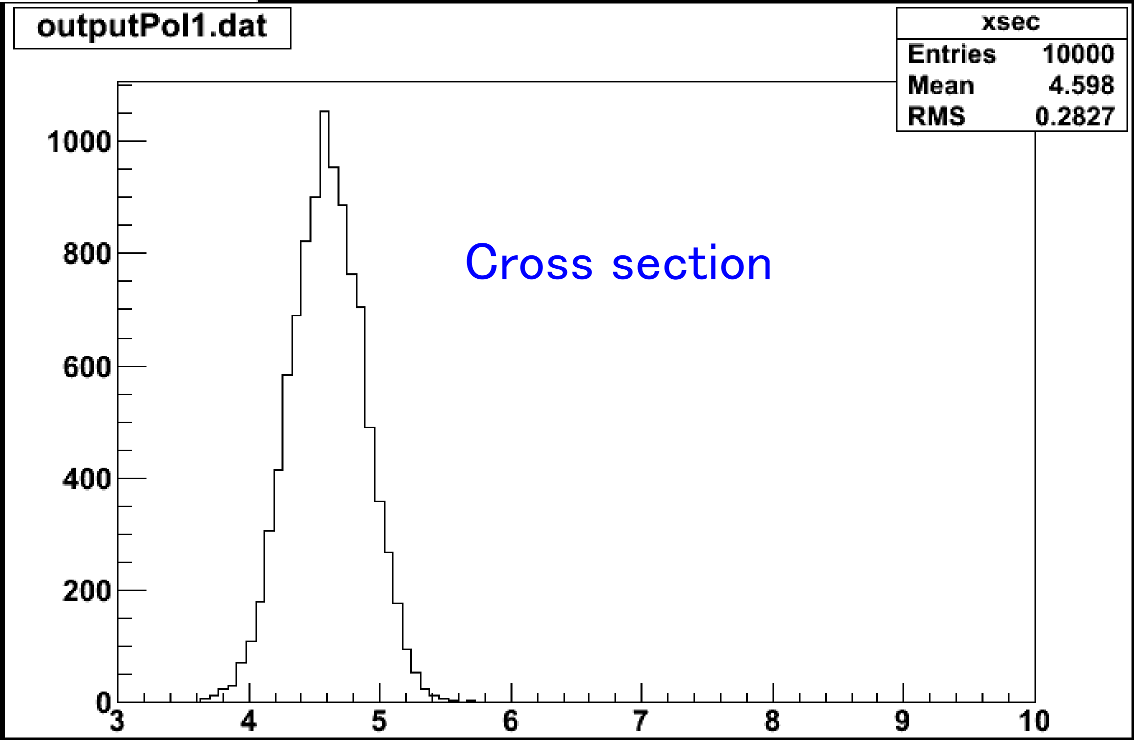
" real Nsig = 1730"

Consistent within error ranges



(+0.8,− 0.3)

Sqrt(s)=350 GeV
Toy MC
10000 seeds

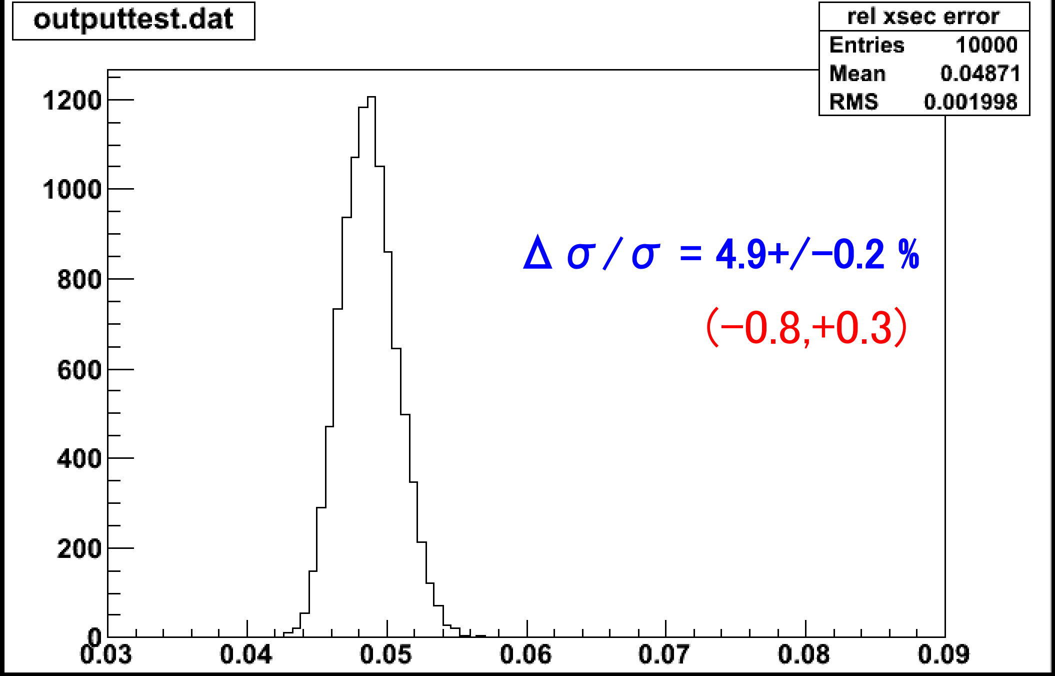


“real xsec = 4.643”

“ real Nsig = 739”

Consistent within error ranges

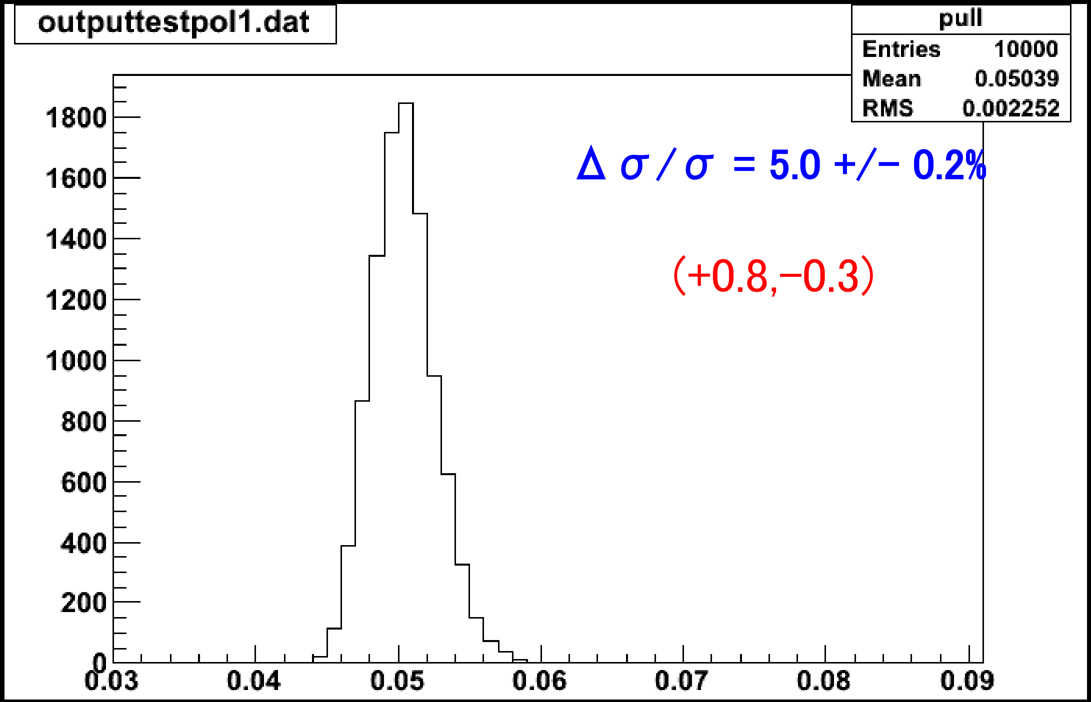
Relative Cross section error

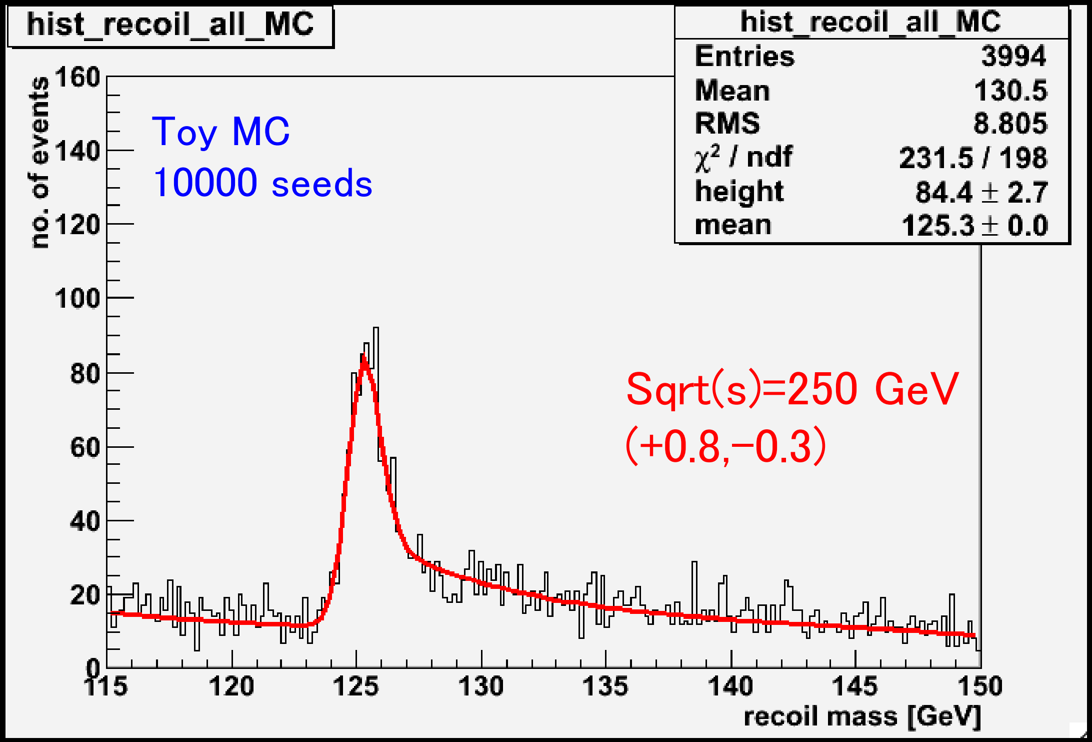


Sqrt(s)=350 GeV

Toy MC 10000 seeds

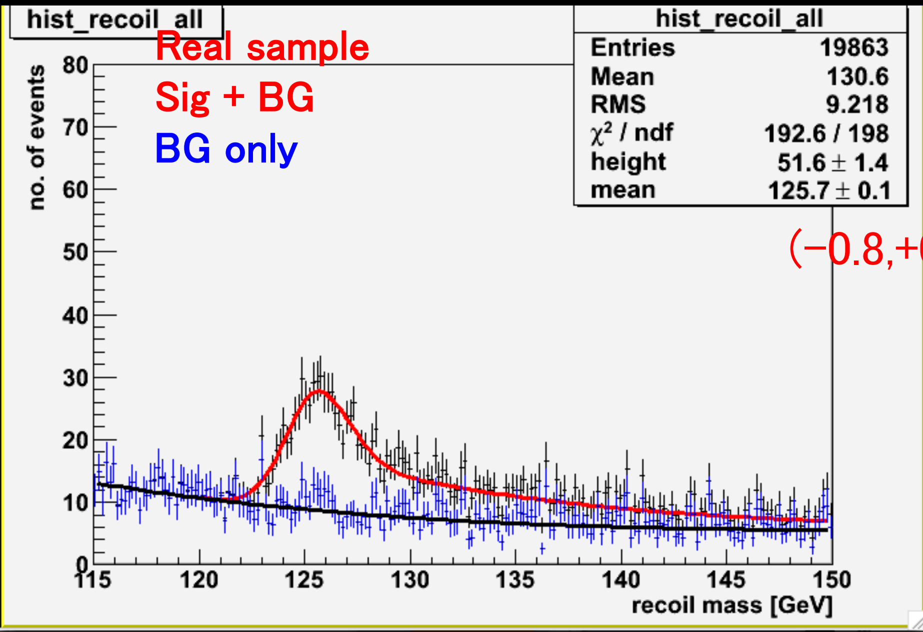
for the two polarization scenarios:
Relative cross section error consistent within ranges of RMS spread

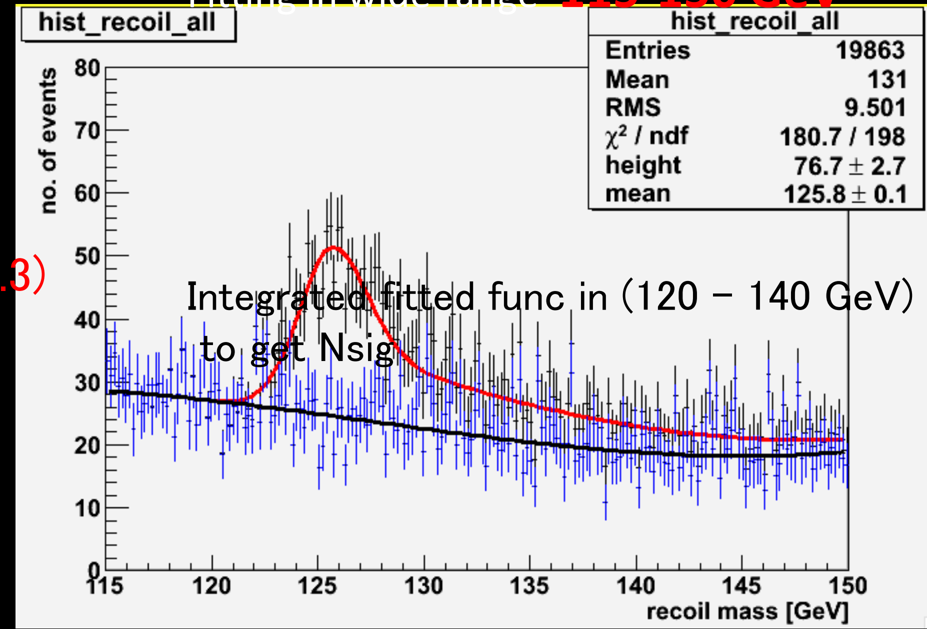


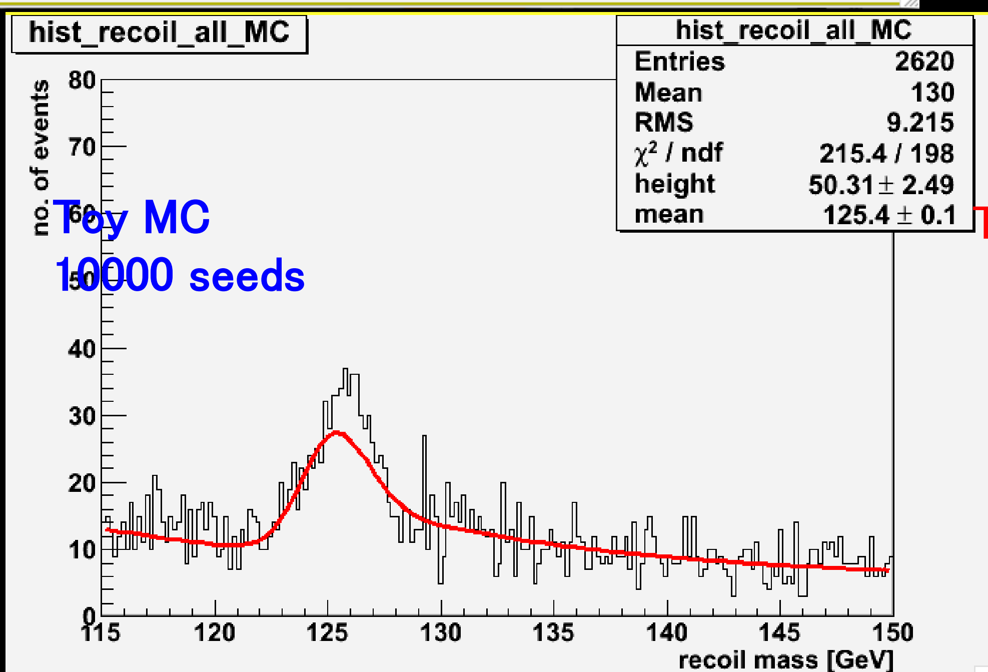


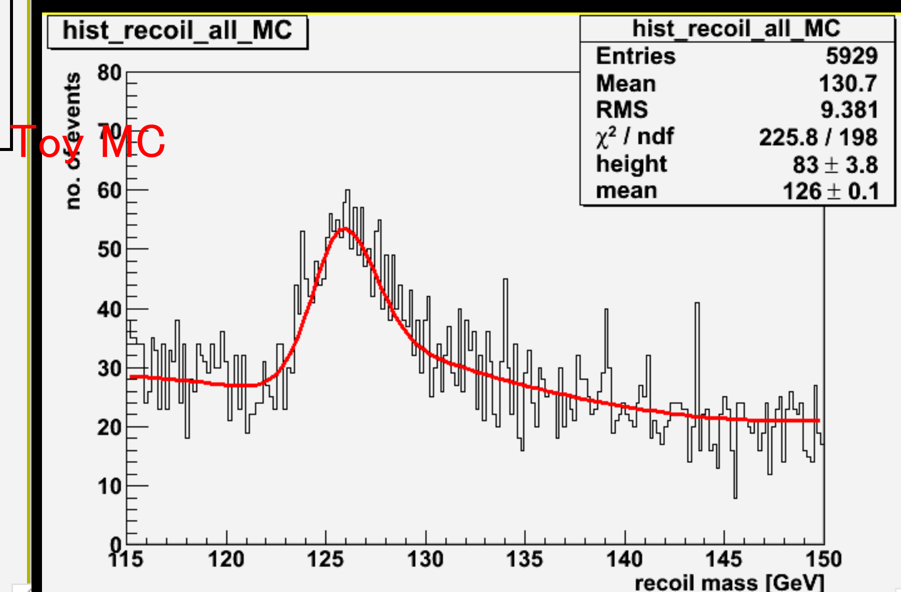
Input #of events according to
Poisson distr (mean = real # of input)

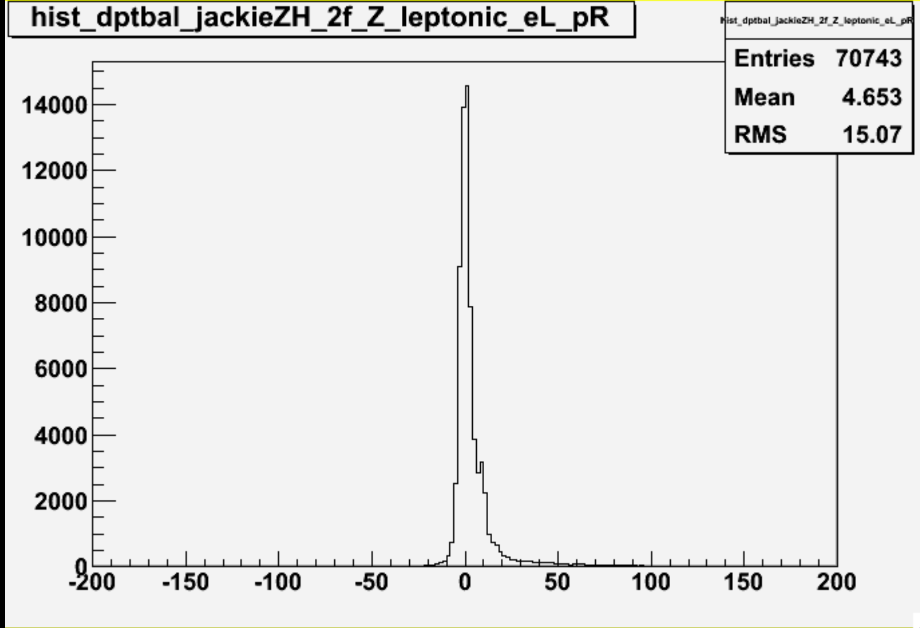
Fitting in wide range 115-150 GeV







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RMS 15.07
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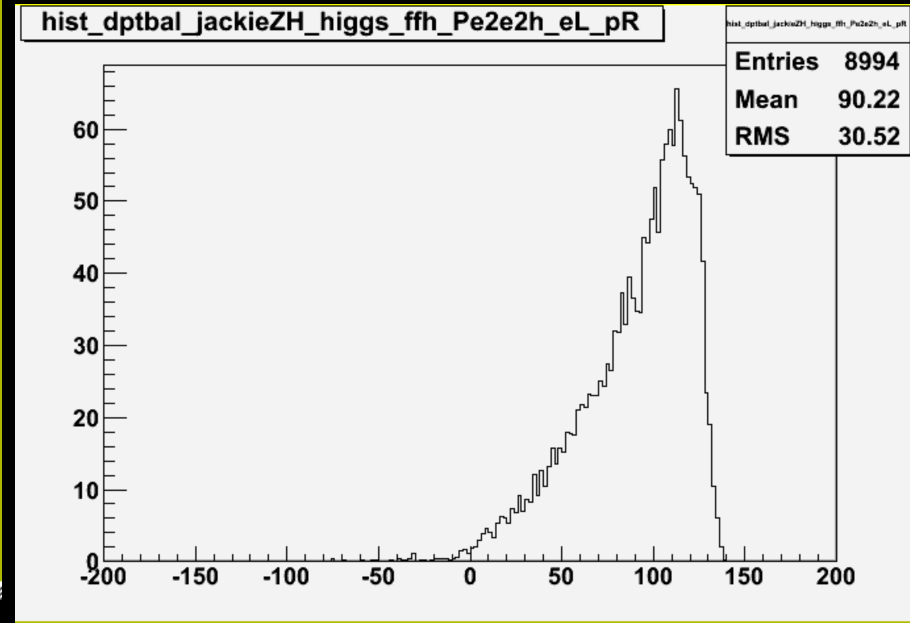
12000
10000
8000
6000
4000
2000
0
-200 -150 -100 -50 0 50 100 150 200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Mean 90.22
RMS 30.52
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50
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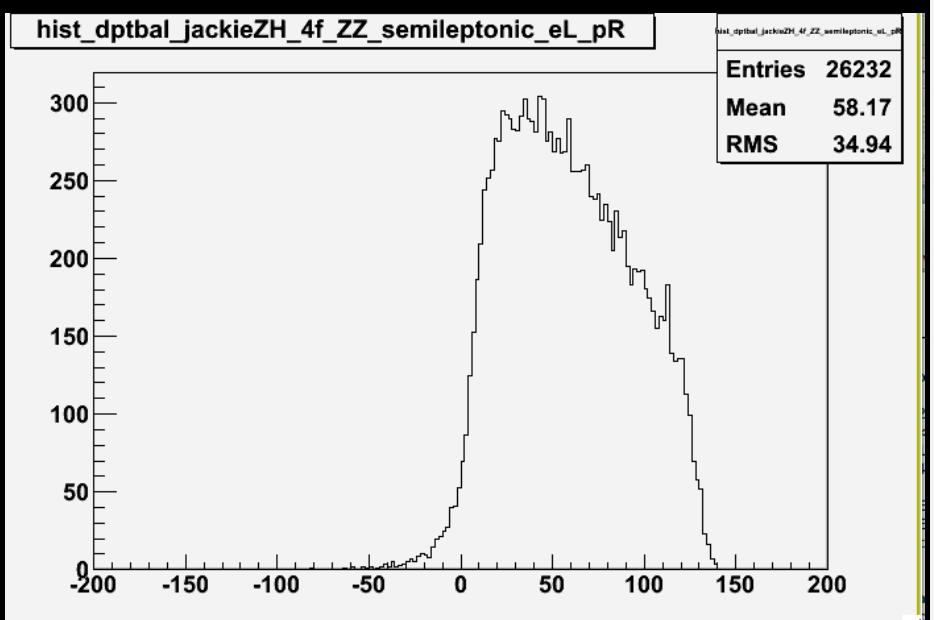
30
20
10
0
-200 -150 -100 -50 0 50 100 150 200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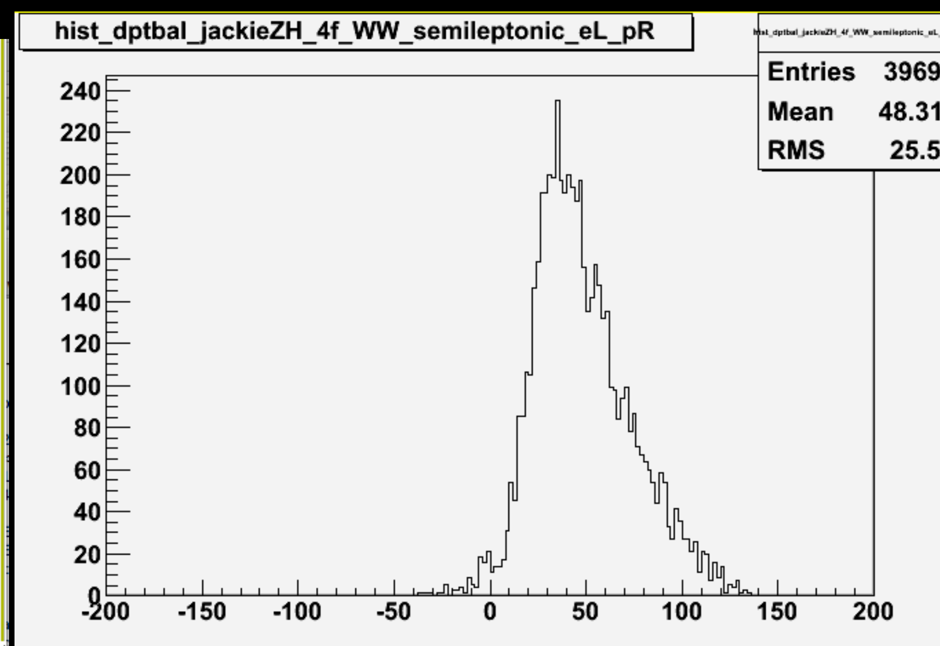
100
50
0
-200 -150 -100 -50 0 50 100 150 200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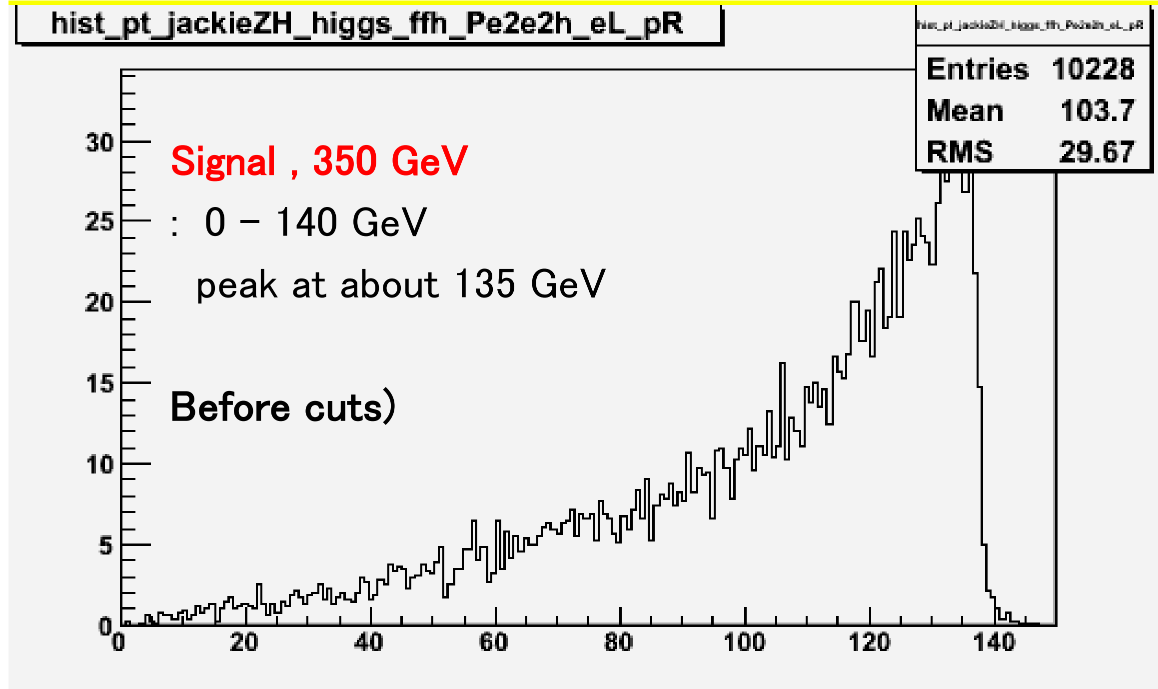
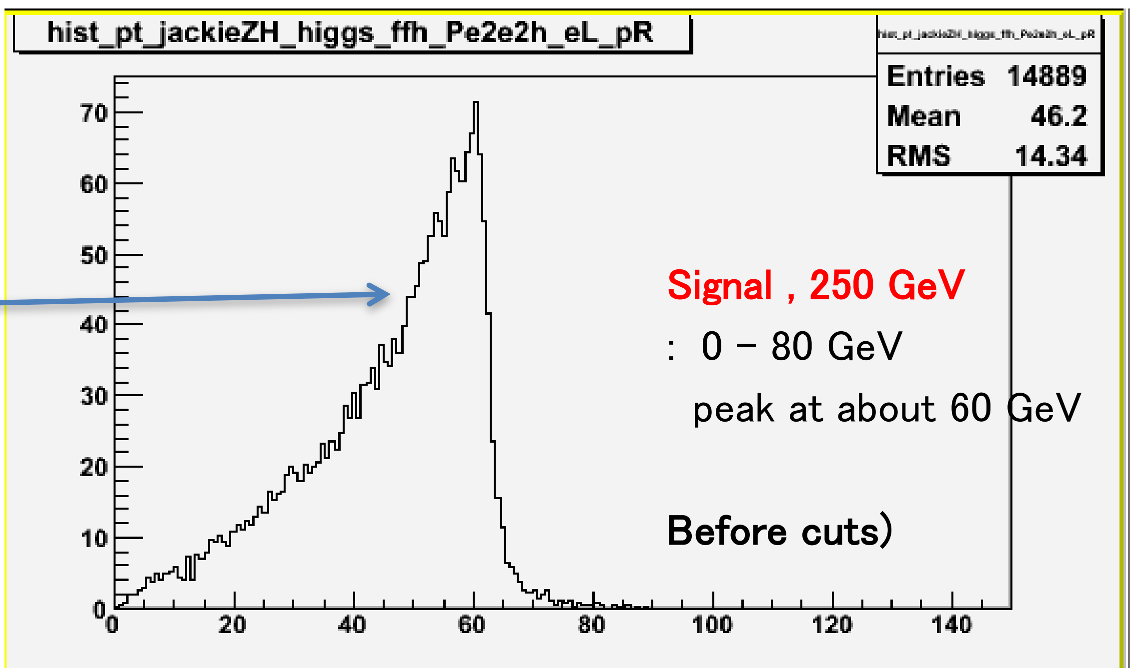
Entries 3969
Mean 48.31
RMS 25.5
240
220
200
180
160
140
120
100
80
60
40
20
0
-200 -150 -100 -50 0 50 100 150 200

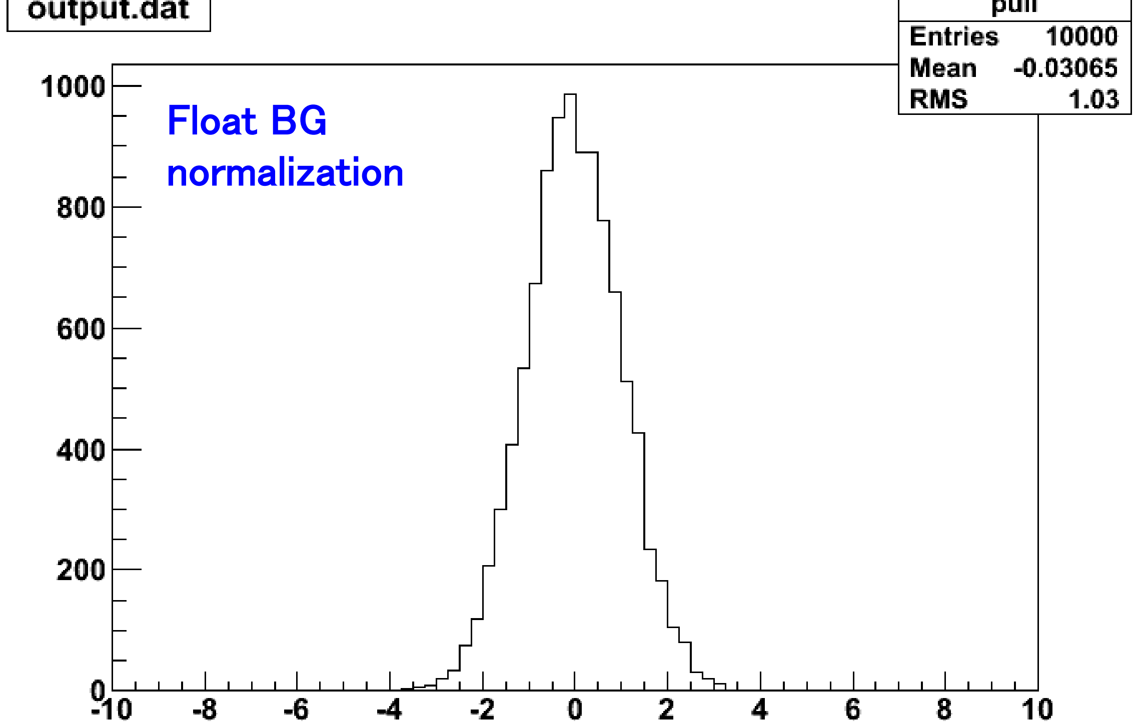
dilepton PT, 350 GeV

do cut :

10 GeV< pT_dl < 140 GeV





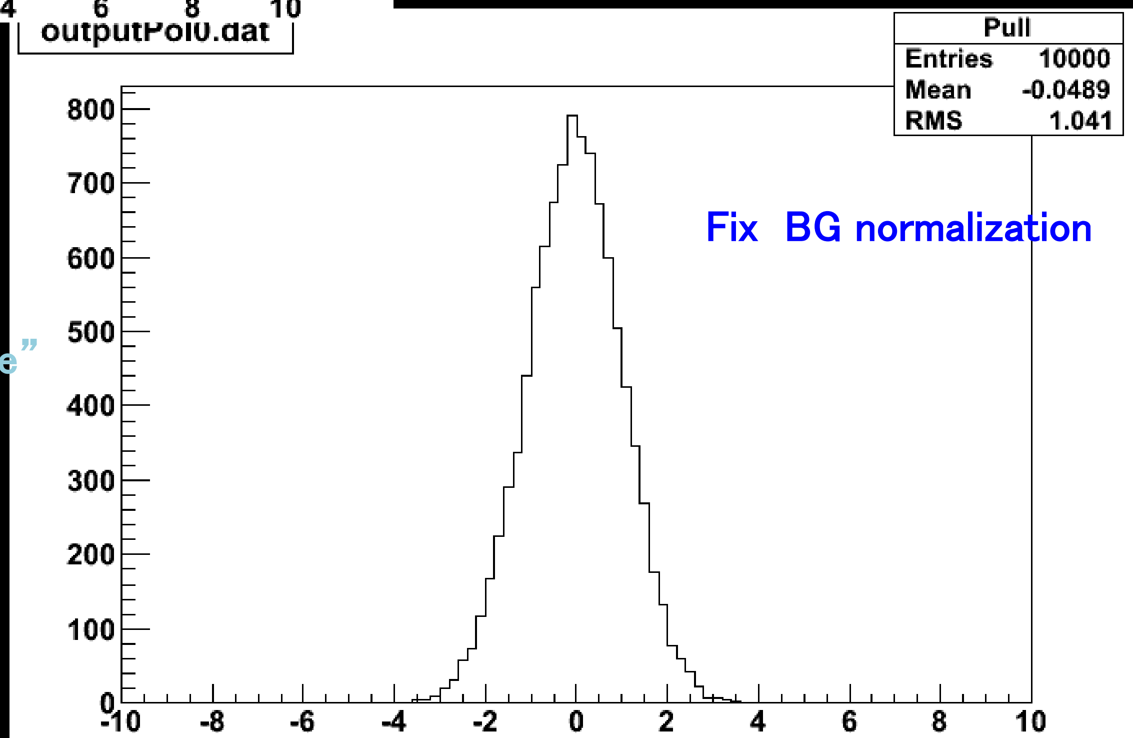


Pull plot

Toy MC
10000 seeds

rms close to 1

mean is more biased for “fix BG case”



Signal sample:

Pe2e2h_.eL.pR & Pe2e2h._eR.pL

relevant BG process for Zmumu

- 4f_ZZ_leptonic
- 4f_ZZ_semileptonic
- 2f_Z_leptonic
- 4f_WW_leptonic
- 4f_WW_semileptonic
- 4fSingleZee_leptonic
- 4fSingleZnunu_leptonic
- 4f_ZZWWMix_leptonic
- 6f backgrounds (sqrt(s)=350 GeV)

after all cuts, dominant BG are:

sqrt(s) = 250 GeV : #1) 2f_Z_l #2) 4f_ZZ_sl #3) 4f_ZZWWMix_l

sqrt(s) = 350 GeV : #1) 4f_ZZ_sl #2) 2f_Z_l #3) 4f_WW_sl

no ttbar BG left after data selection

- **preliminary comparison of cut efficiency between MC truth and reconstructed for 350 GeV**
signal and a few dominant BGs : integrated under histograms, counted in region 123-135 GeV

Rec

cut	signal	eff	4f_ZZ_sl	eff	2f_Z_l	eff
raw	2288	100%	188087	100.00%	2226361	100.00%
only best mu pair	2214	97%	25217	13.41%	329581	14.80%
cos(trackAng)<0.98	2202	96%	19906	10.58%	305146	13.71%
84 <M_inv <98	1824	80%	5314	2.83%	94671	4.25%
10 <P_Tdl<140	1817	79%	5198	2.76%	26063	1.17%
copl < 3	1790	78%	4853	2.58%	22766	1.02%
cos(θ Z)<0.91	1707	75%	3672	1.95%	10765	0.48%
120 GeV <M_rec <140 GeV	1089	48%	1133	0.60%	1050	0.05%

MC

cut	signal	eff	4f_ZZ_sl	eff	2f_Z_l	eff
raw	2288	100%	188087	100.00%	2226361	100.00%
only best mu pair	2288	100%	26219	13.94%	417982	18.77%
cos(trackAng)<0.98	2208	97%	17385	9.24%	306297	13.76%
84 <M_inv <98	1981	87%	5115	2.72%	102691	4.61%
10 <P_Tdl<140	1945	85%	5006	2.66%	24539	1.10%
copl < 3	1945	85%	4691	2.49%	24539	1.10%
cos(θ Z)<0.91	1852	81%	3599	1.91%	11813	0.53%
120 GeV <M_rec <140 GeV	1256	55%	1056	0.56%	986	0.04%