Higgs recoil mass study

ILC Physics Meeting
3/27/2015

Jacqueline Yan (Univ. of Tokyo)

This week's new results

Xsec error reached

3.79% for 350 GeV

and

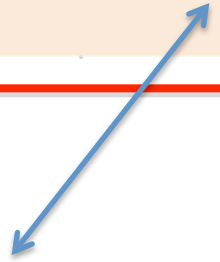
2.92% for 250 GeV

Signal efficiency and BG rejection improved

S/B ratio = 85% for 350 GeV and 98% for 250 GeV

Improvements in results

cuts	(both eLpR and eRpL) Nsig	Nbg	S/B ratio	significance	sig eff (before Mrec)	Δσ/σMC)	
Ecm=350 GeV							
1 week ago	1174	1871	0.63	21.3	56% (89%)	4.01%	(RMS: 0.13%)
current (best result)	1196	1407	0.85	23.4	57% (87%)	3.79%	(RMS: 0.11%)
Ecm=250 GeV							
current	1735	1764	0.98	29.3	75% (82%)	2.92%	(RMS: 0.06%)



compare with results from 2014 AWLC 14

250 GeV	Sig eff	xsec err	S/B	significance
(−0.8,+0.3)	66.4+/−0.5%	3.6 %	0.37	21.7

Final Selection Last Week

- 73 GeV < M_inv < 120 GeV
- 10 GeV < pT_mumu < 140 GeV
- **Econe_γ > 40 GeV || Ebal < 260 GeV**
- **dptbal = pT_mumu – pTγ_max > 20 GeV**
- |cos(θ_Zpro)| < 0.9
- 120 GeV < Mrecoil < 140 GeV

Final Selection NEW

- 73 GeV < M_inv < 120 GeV
- 10 GeV < pT_mumu < 140 GeV
- **Econe_γ > 5 GeV**
- **Ebal < 280 GeV**
- **Econe_γ > 10 GeV || Ebal < 270 GeV (*)**
- **dptbal > 10 GeV**
- **dptbal > 30 GeV || Ebal < 230 GeV (*)**
- |cos(θ_Zpro)| < 0.9
- 120 GeV < Mrecoil < 140 GeV

definition

- 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

- Econe_mu: cone energy (cosθ>0.9) around muon
- Econe_γ: cone energy (cosθ>0.9) around most energetic γ
- Pt_sum = |Pt_dl – Pt_γ| (in vectors)

(*) used in coincidence with extra requirements to prevent signal loss

Improvements in results

(only eLpR)

cuts	after Minv, pt	after Econe_γ	after dptbal	final
this week (last week)				
signal	1.93E+03	1880 (1920)	1851 (1875)	1152 (1130)
2f_Z_l	8.20E+04	1.1E4 (5.5E4)	3791 (4807)	61 (72)
4f_ZZWWMix_l	1.90E+04	2349 (1.9E4)	1844 (1.6E4)	50 (323)

- Improvised a data selection method using combined info of

Part 1: Econe_γ and Ebal = Eγ+E_dl

Part 2: dptbal and Ebal

Optimized while observing 2D distribution → divide into regions

- Ultimate purpose: cut as much BG as possible while preserving signal
- Now we cut not only 2f_Z_leptonic but also effective on 4f_ZZWWMix_leptonic, 4f_Z_leptonic, 4f_singleZnunu_leptonic
- Likelihood distribution changed → now works more efficiently

- I realized the less sophisticated cuts I used before were not that effective

dominant BG after final selection (Mrec 120–140 GeV + Likelihood cut)

this week (last week)

4f_ZZ_semileptonic : 1085 (990) : *can't do anything*

4f_ZZWWMix_leptonic: 50 (324) : REDUCED !!

4f_Z_leptonic : 93 (211): REDUCED !!

2f_Z_leptonic: 64 (76)

4f_singleZnunu_leptonic: 24 (172) : REDUCED !!

vs

Higgs: 1196 (1174) more signals

The number of events after each selection step is in

/ home/ ilc / jackie / jackieZHProcessornew / data /

350 GeV: output350_150323.dat : this week output_150320.dat : last week

250 GeV: output250_150322.dat (this week)

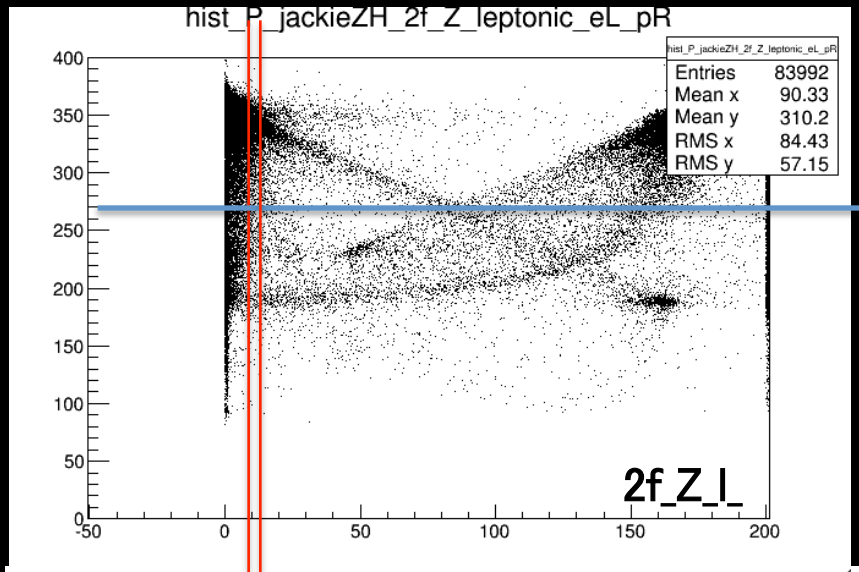
2D distr. Of

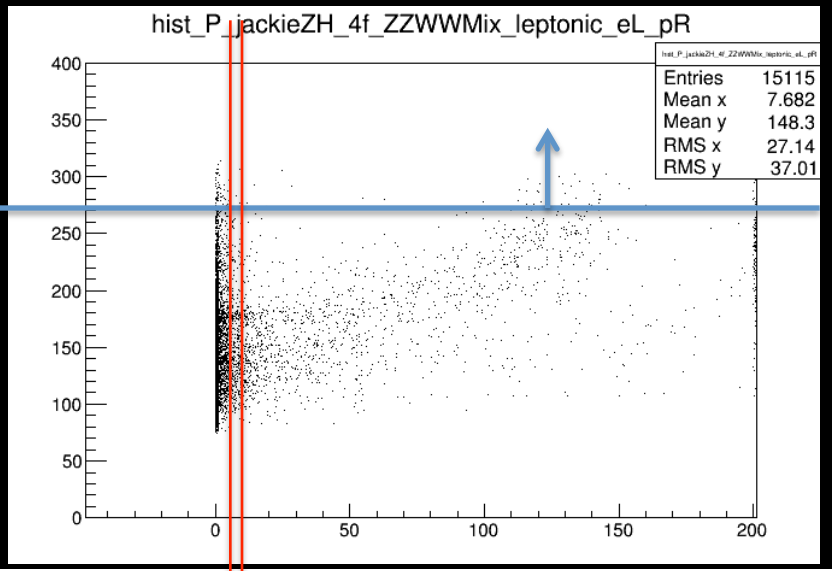
X: Econe_γ

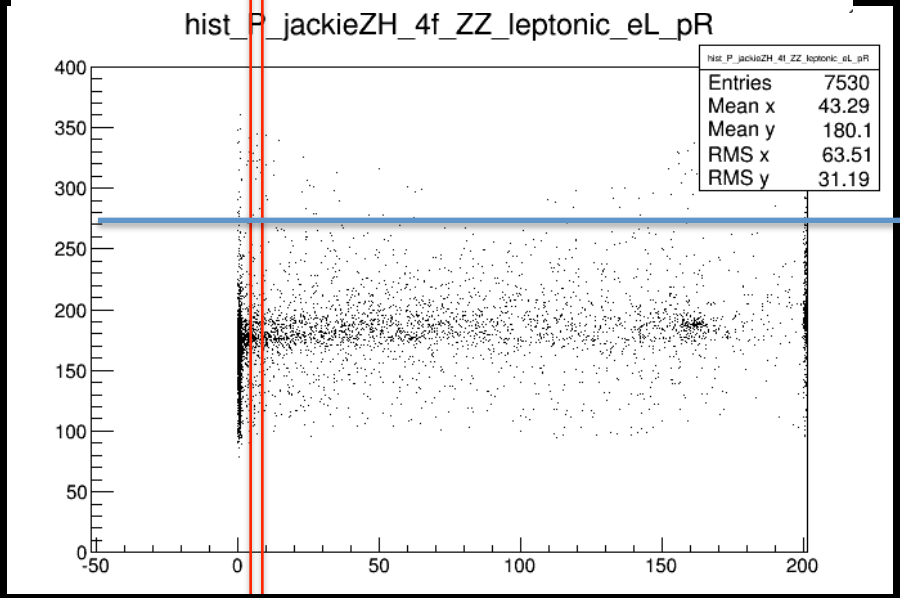
Y: Ebal = Eγ + E_dl

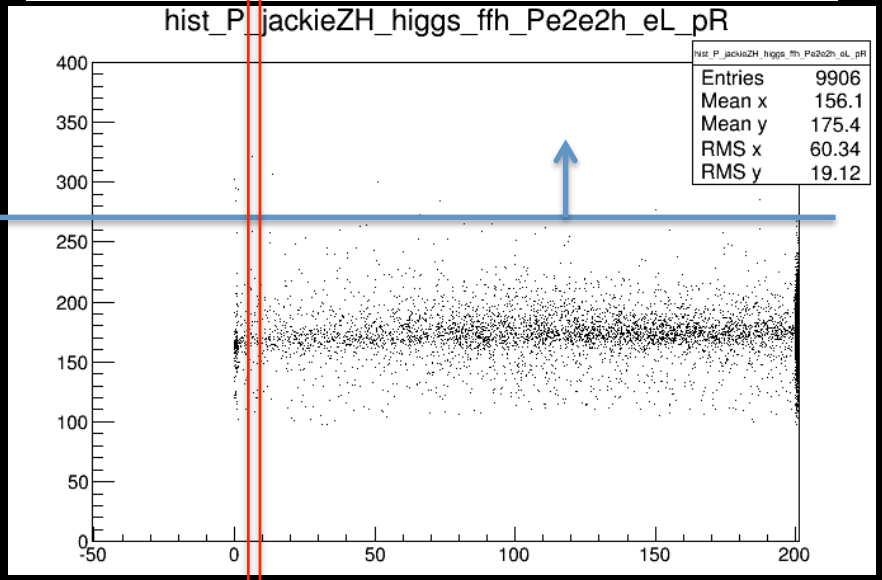
ECM=350 GeV

1. First cut everything Econe γ < 5 GeV
2. Then everything Ebal > 280 GeV)
3. Then cut (Econe γ < 10 GeV && Ebal > 270 GeV







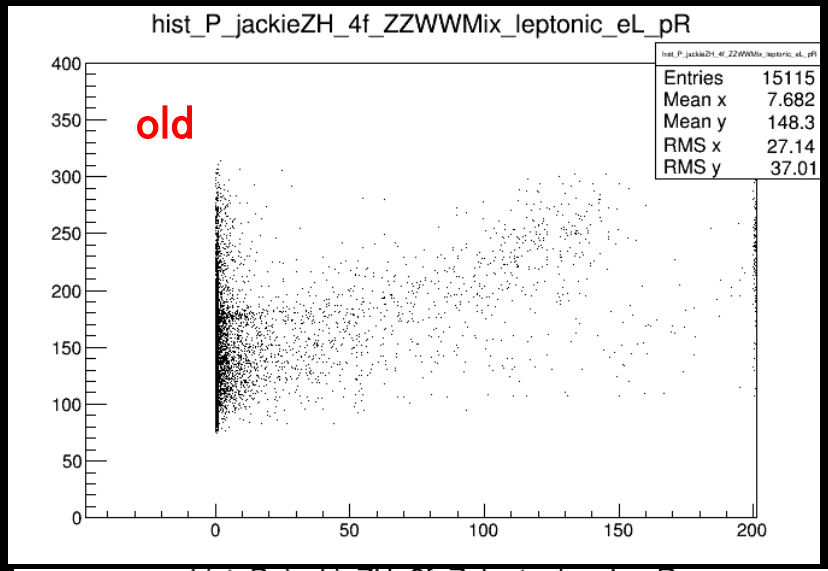


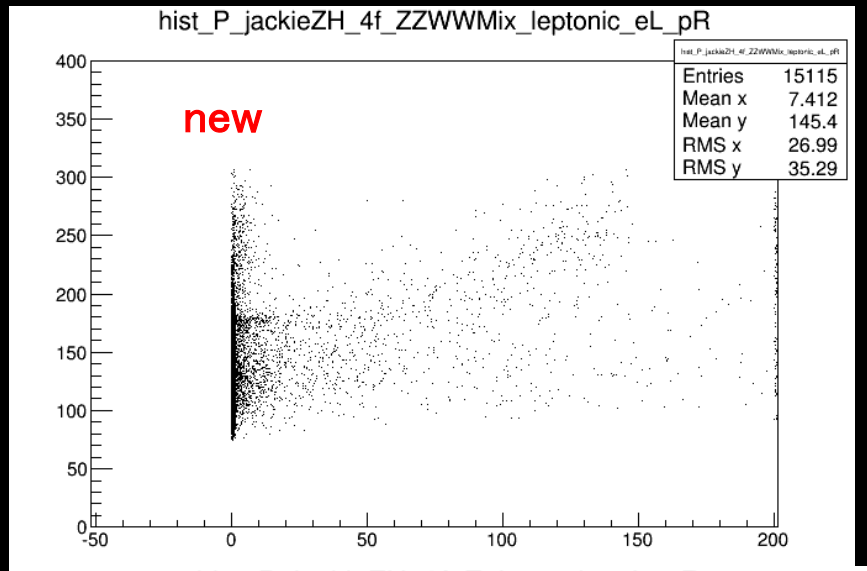
2D distr. Of

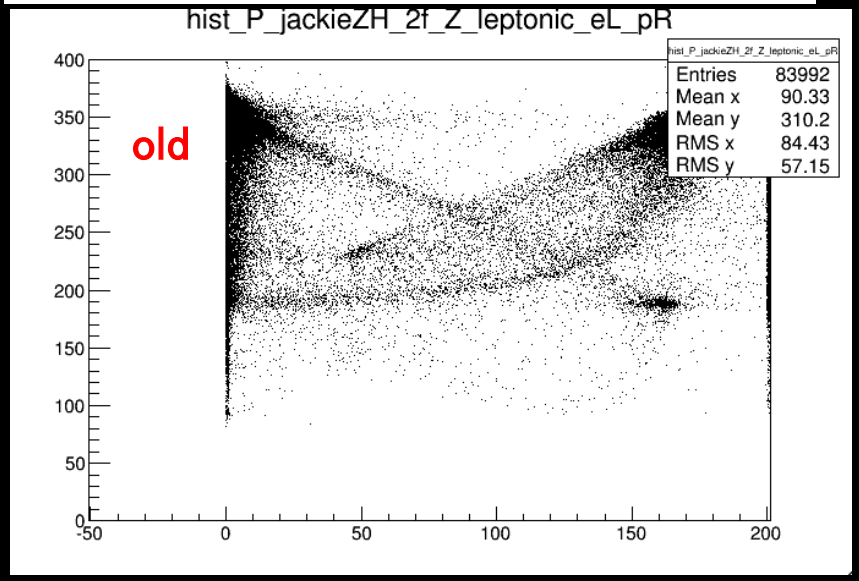
X: Econe_γ

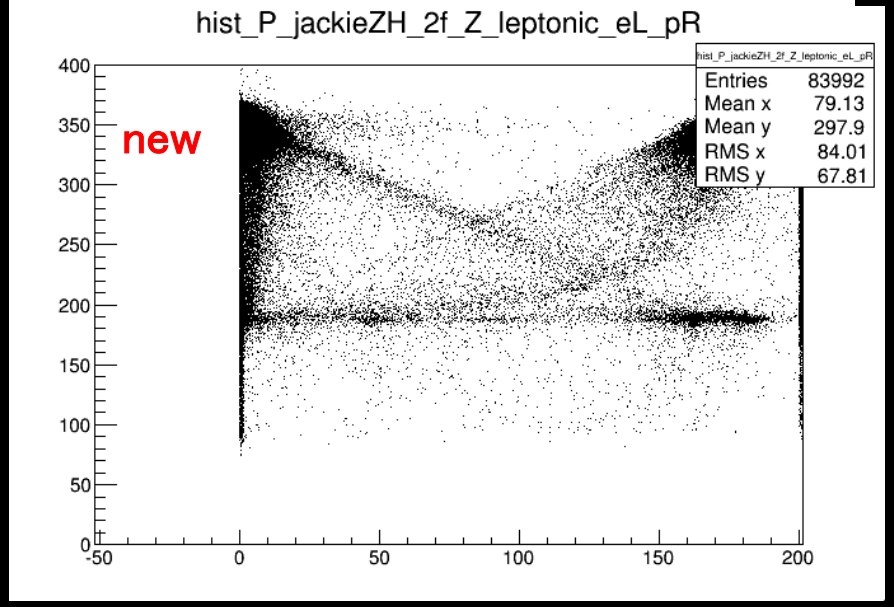
Y: Ebal = Eγ + E_dl

New: corrected condition for selecting photons (EcalE/Etot > 0.9)









2D distr. Of

X: Econe_γ

Y: Ebal = Eγ + E_dl

ECM=350 GeV

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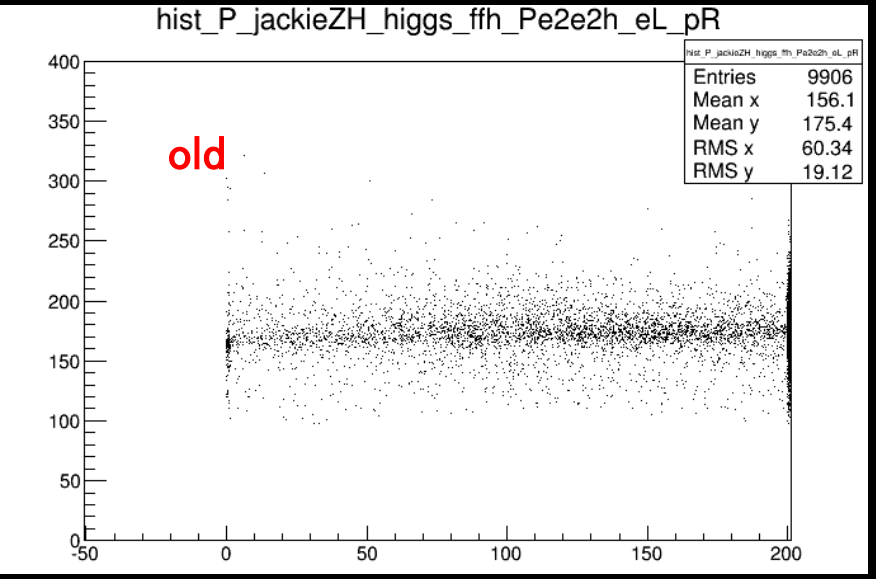
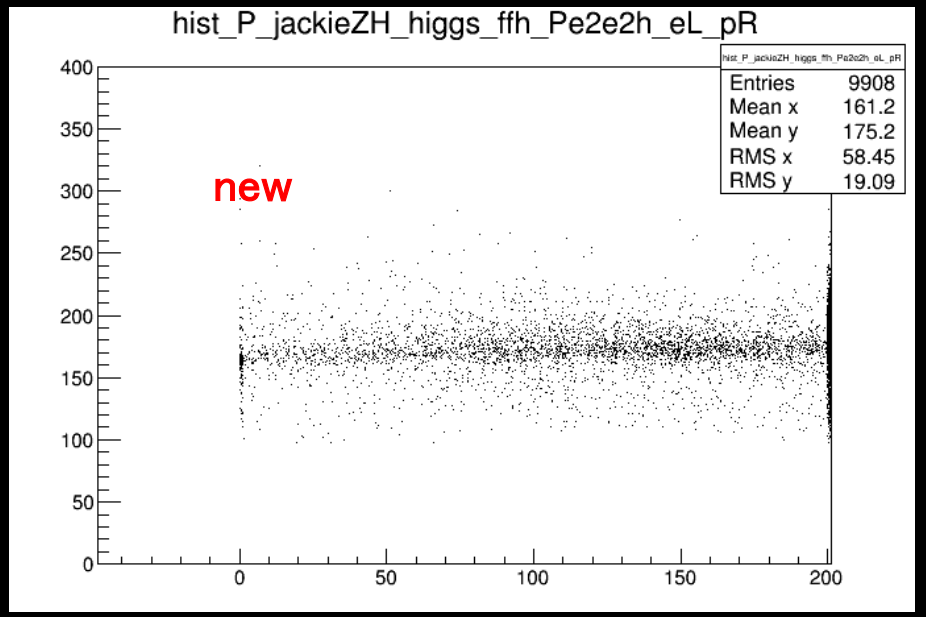
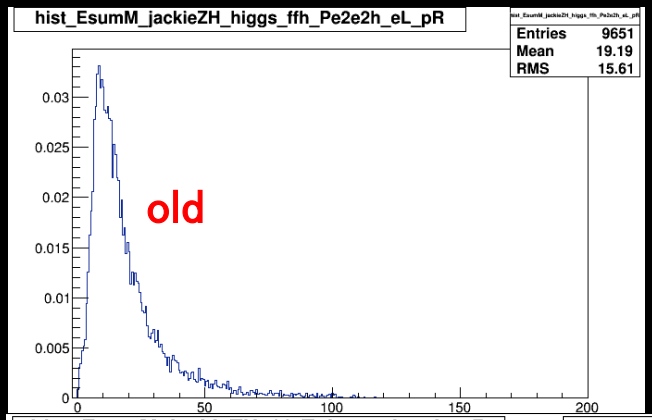


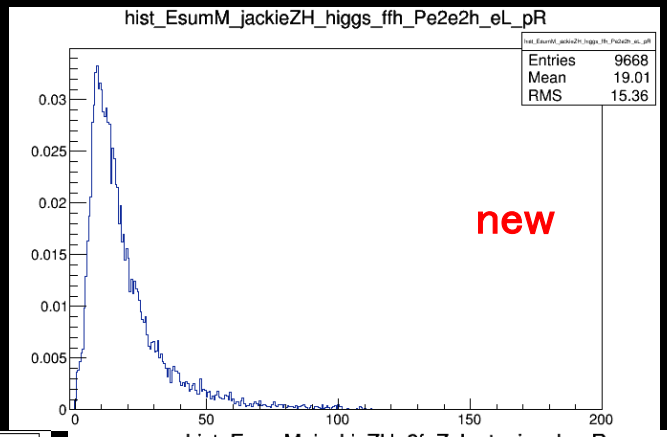


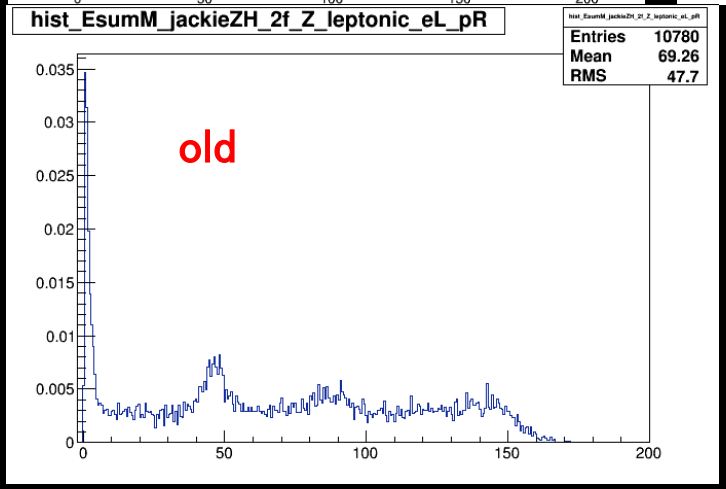
energy of most energetic gamma

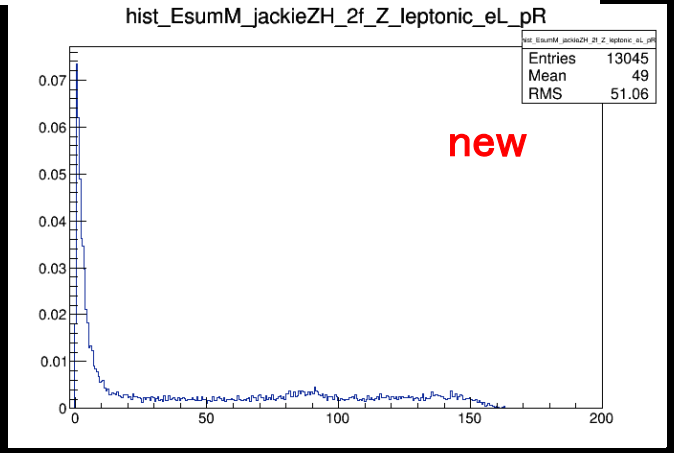
ECM=350 GeV

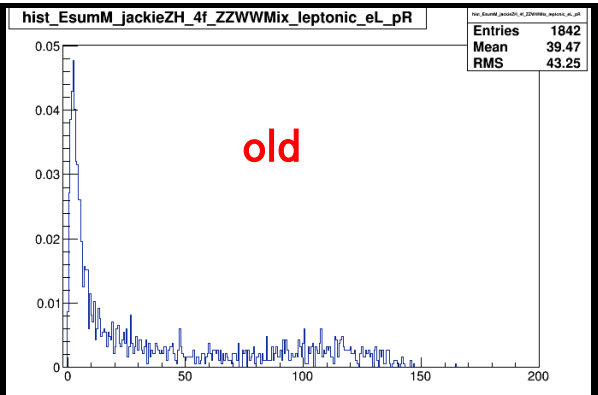
New: corrected condition for selecting photons (EcalE/Etot > 0.9)

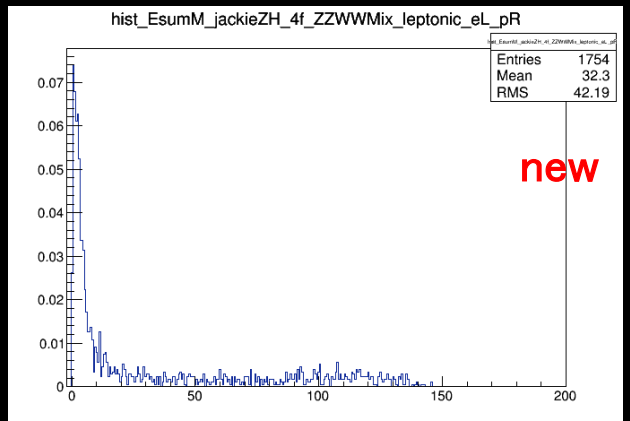












2D distr. Of

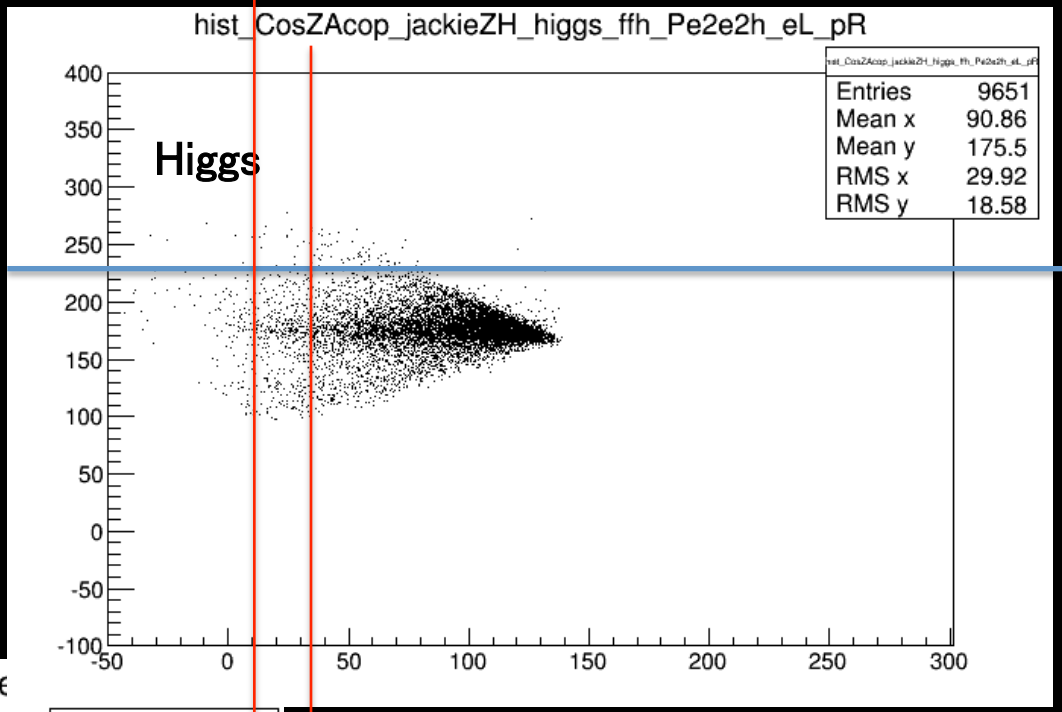
X: dptabl

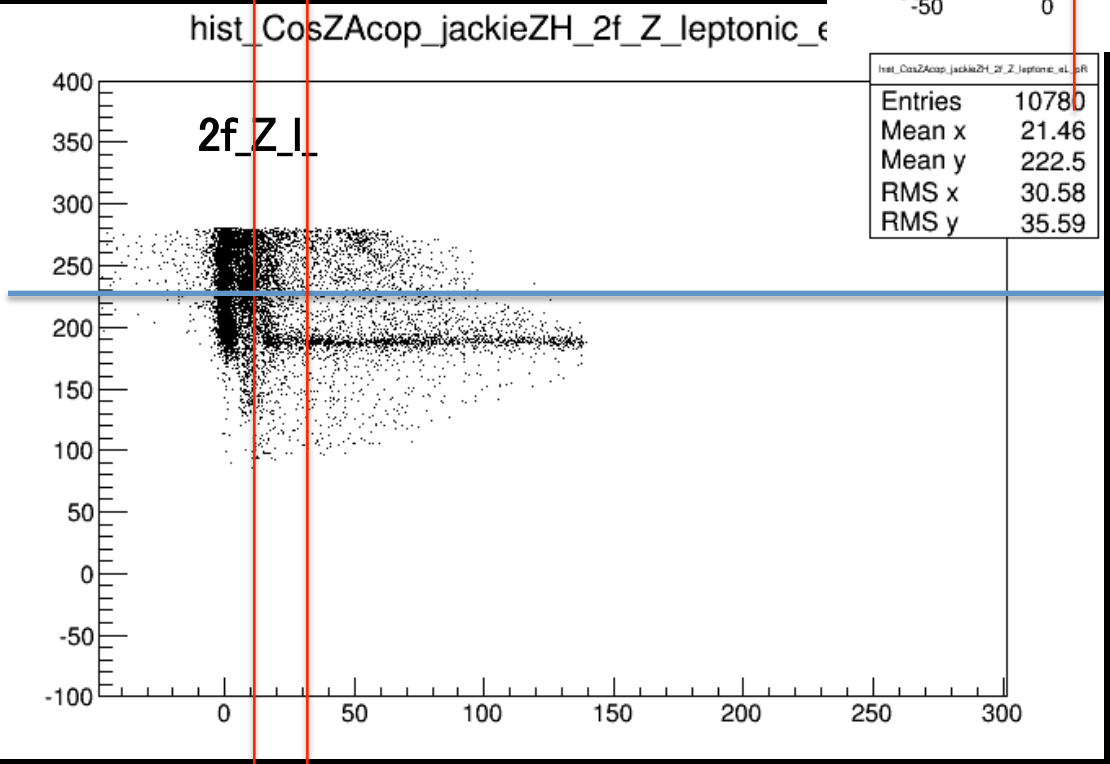
Y: Ebal = E γ + E_dl

Similar done for

X: Econe_γ

Y: Ebal

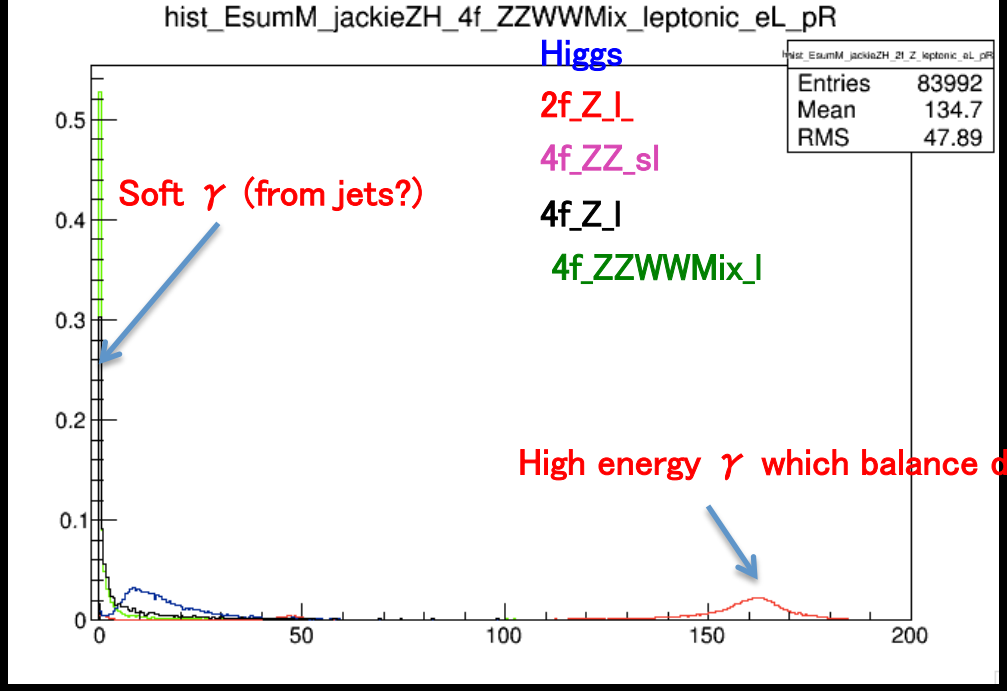




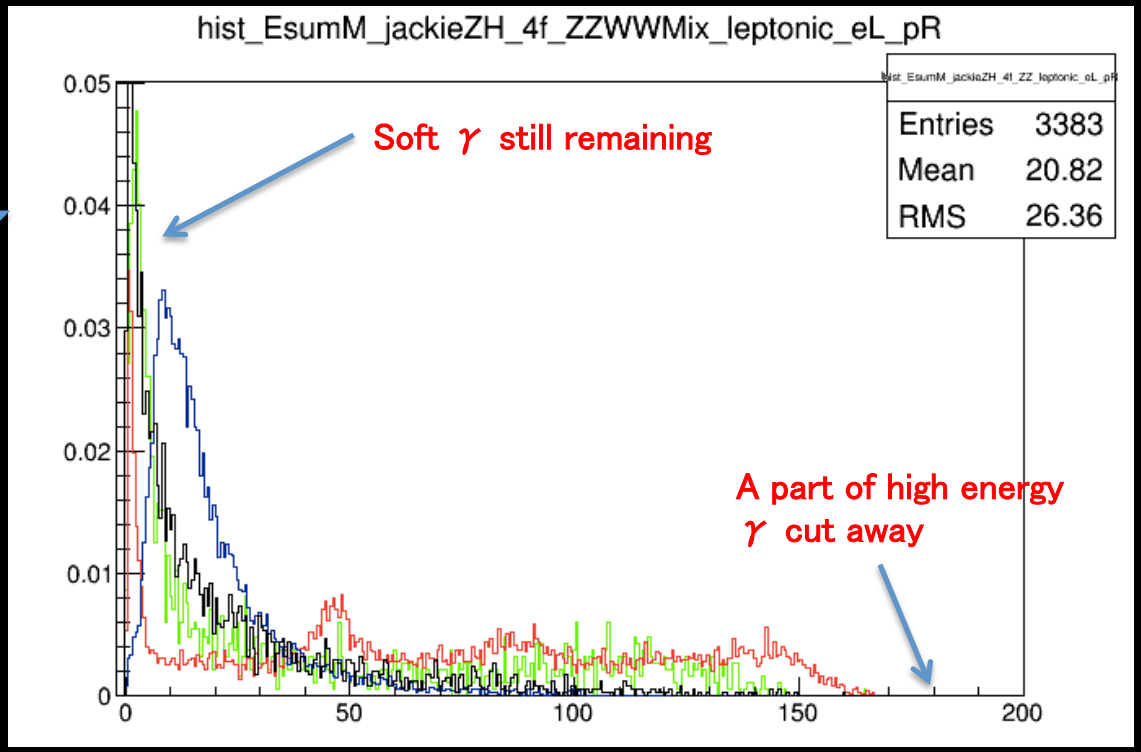
1. First cut everything dptbal < 10 GeV
2. Then cut (dptbal < 30 GeV && Ebal > 230 GeV)

Leave the rest to be cut by likelihood

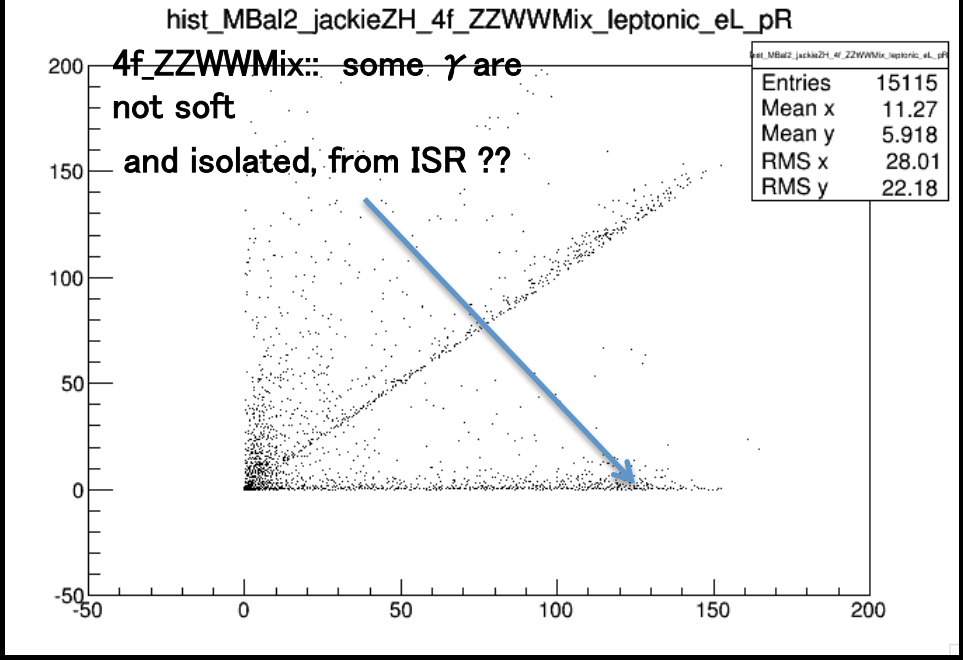
ECM = 350 GeV

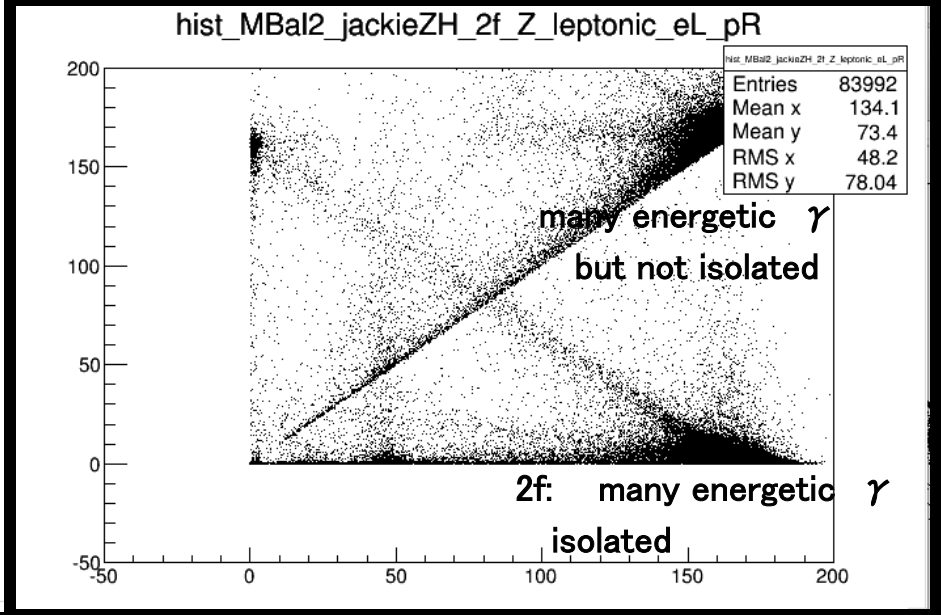


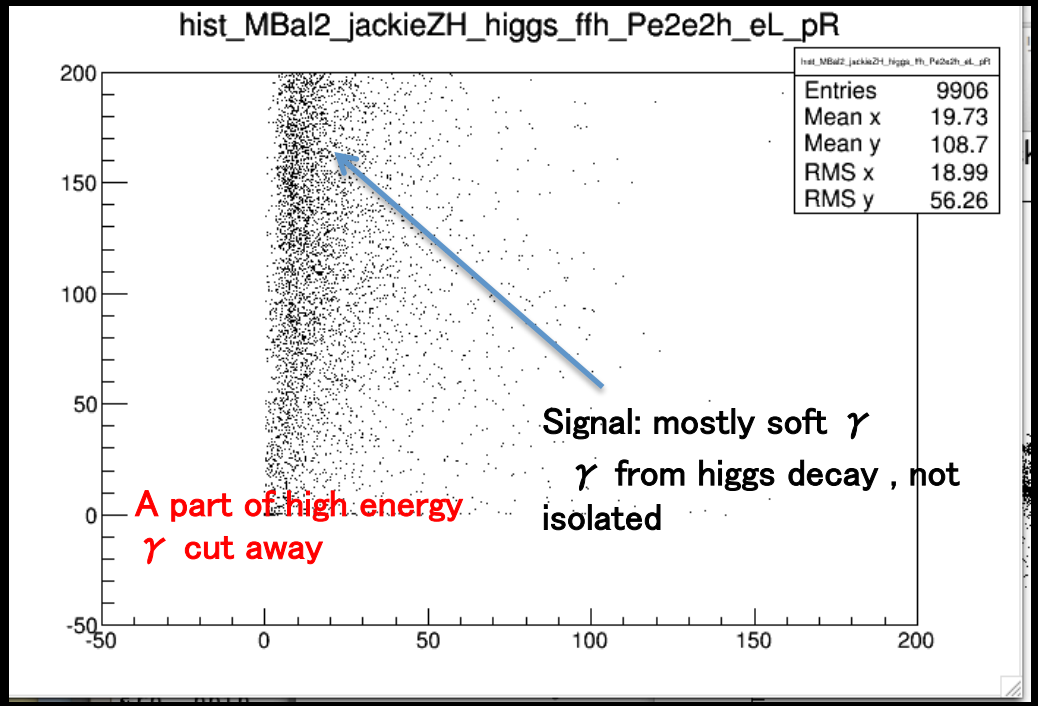
Just after invariant mass cut and Pt cut



After Econe and Ebal cut





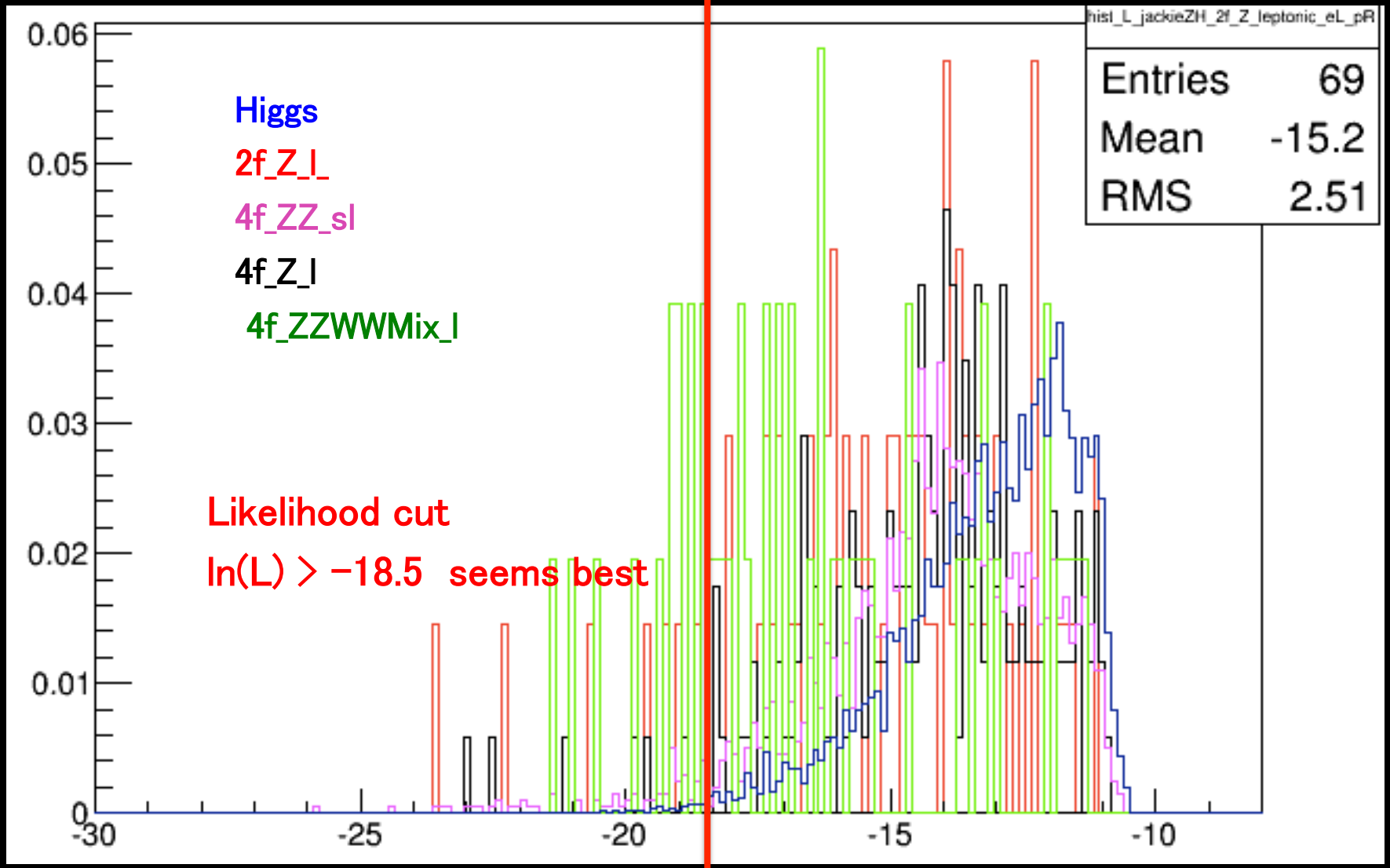


2D distr. Of

X: E γ

Y: Econe_ γ

THIS WEEK: Likelihood function: L = P(M_inv) * P(Pt) * P(CosZ)



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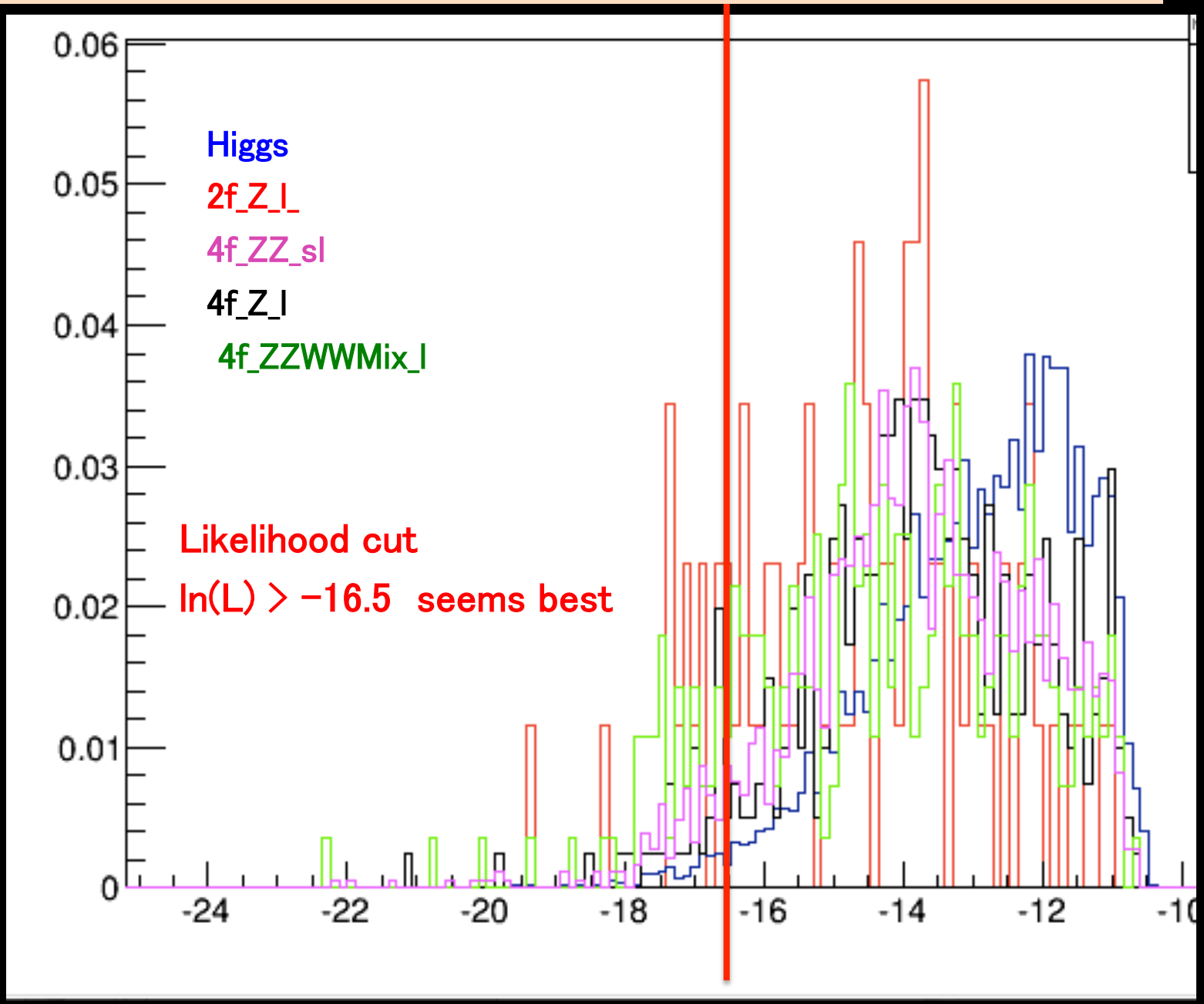
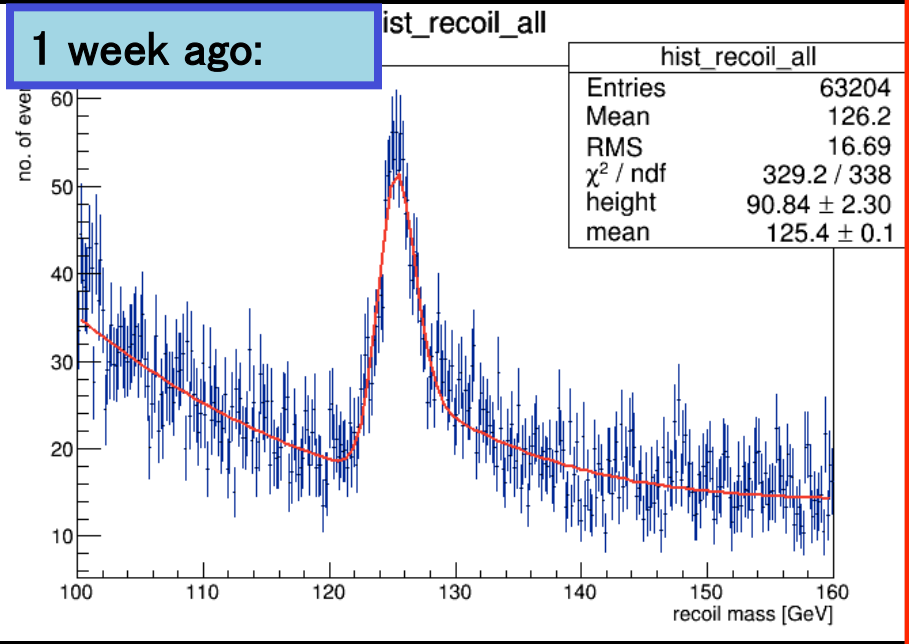
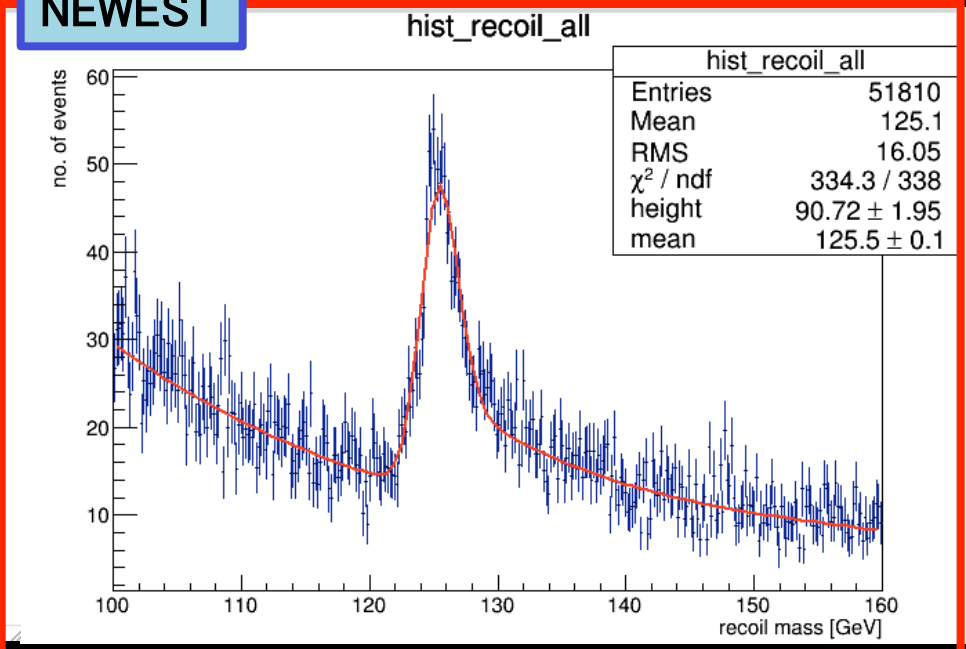
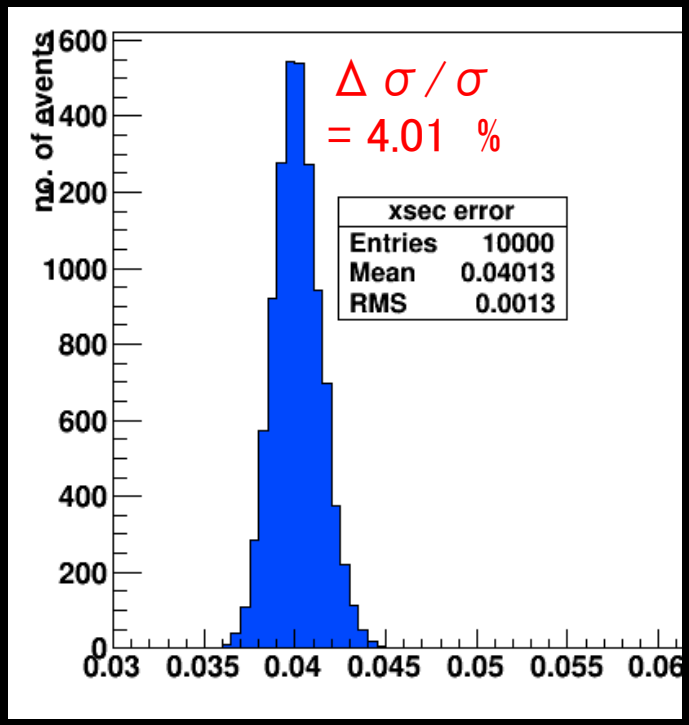


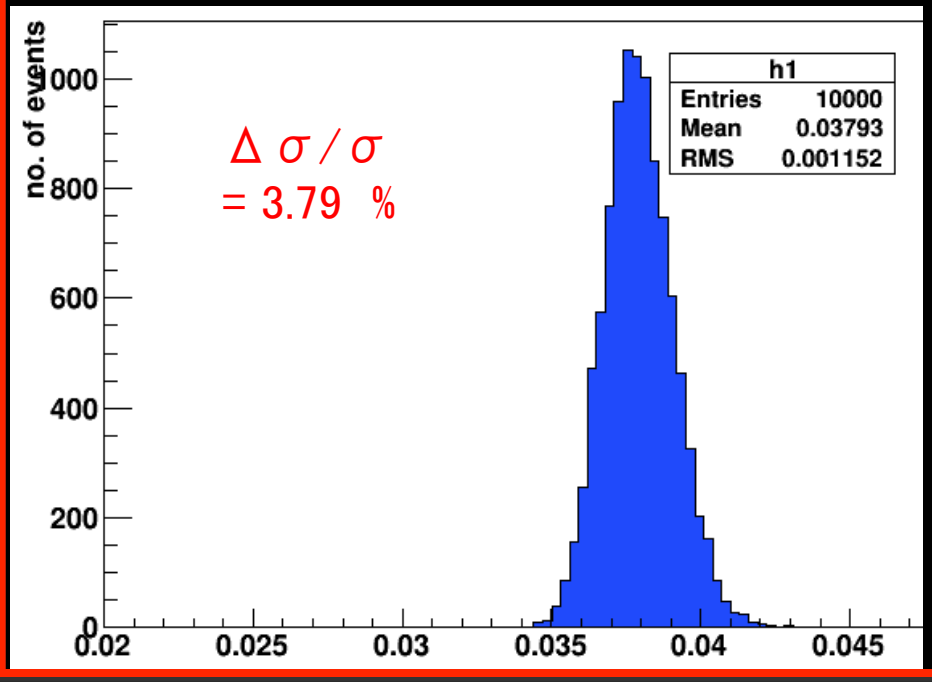
1 week ago:



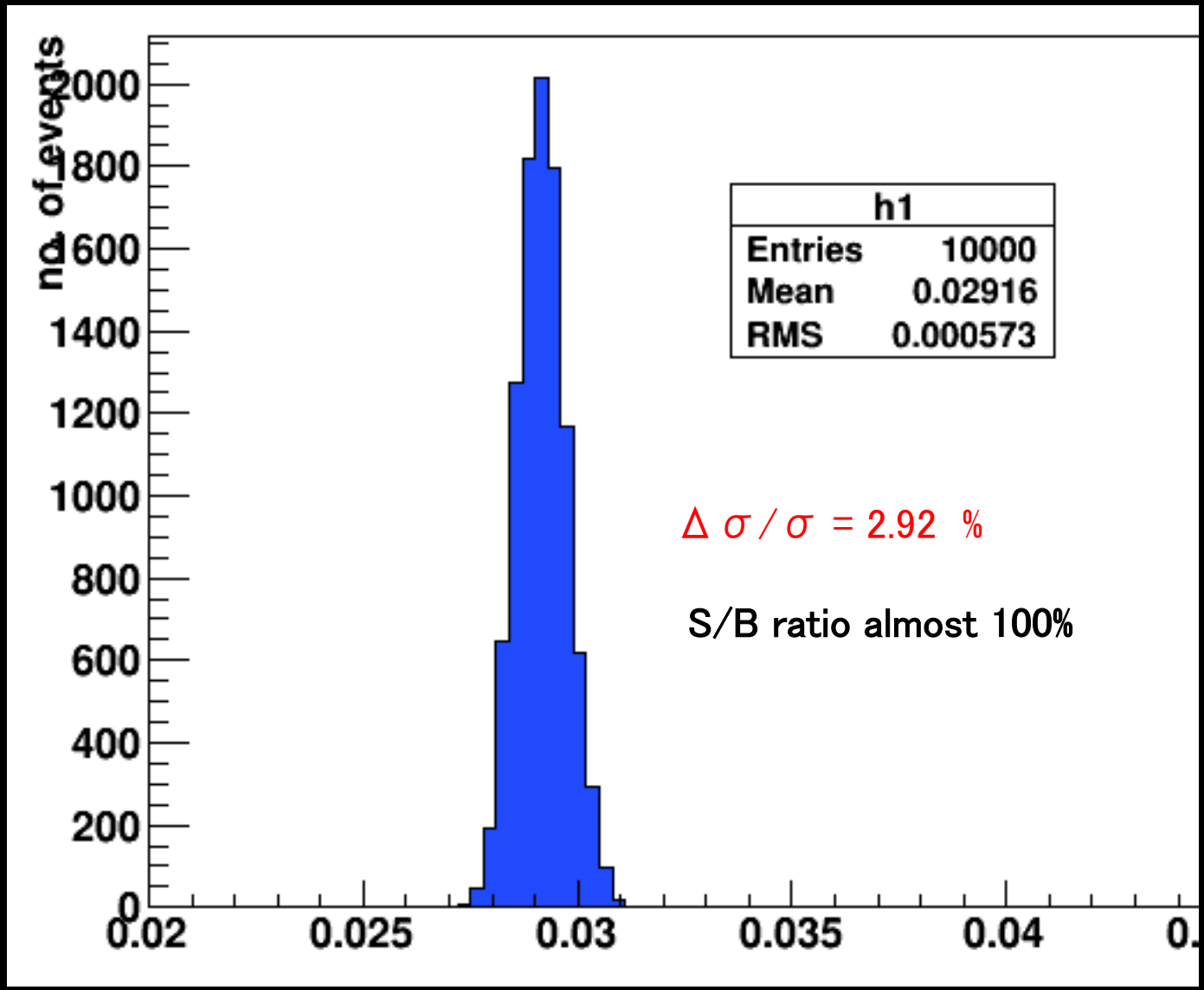
NEWEST



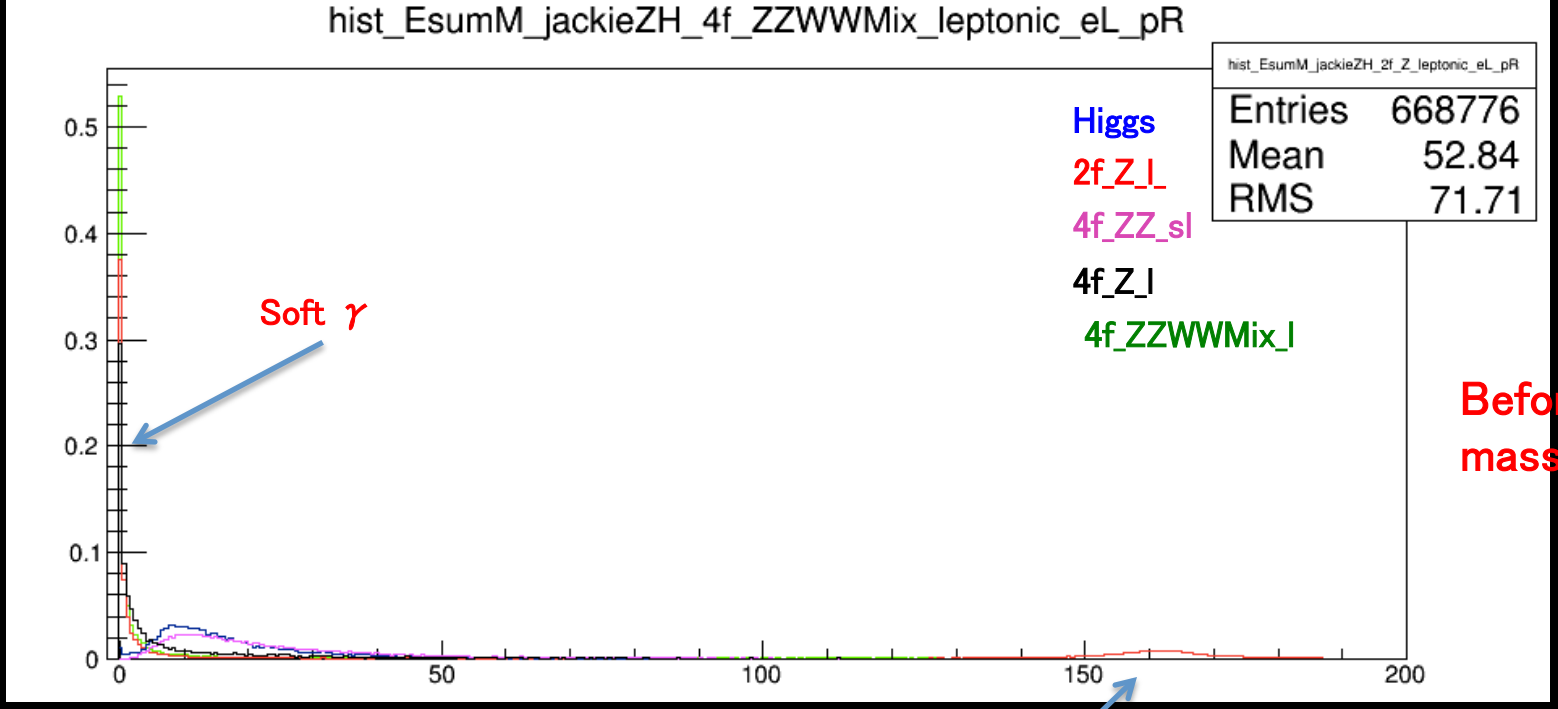




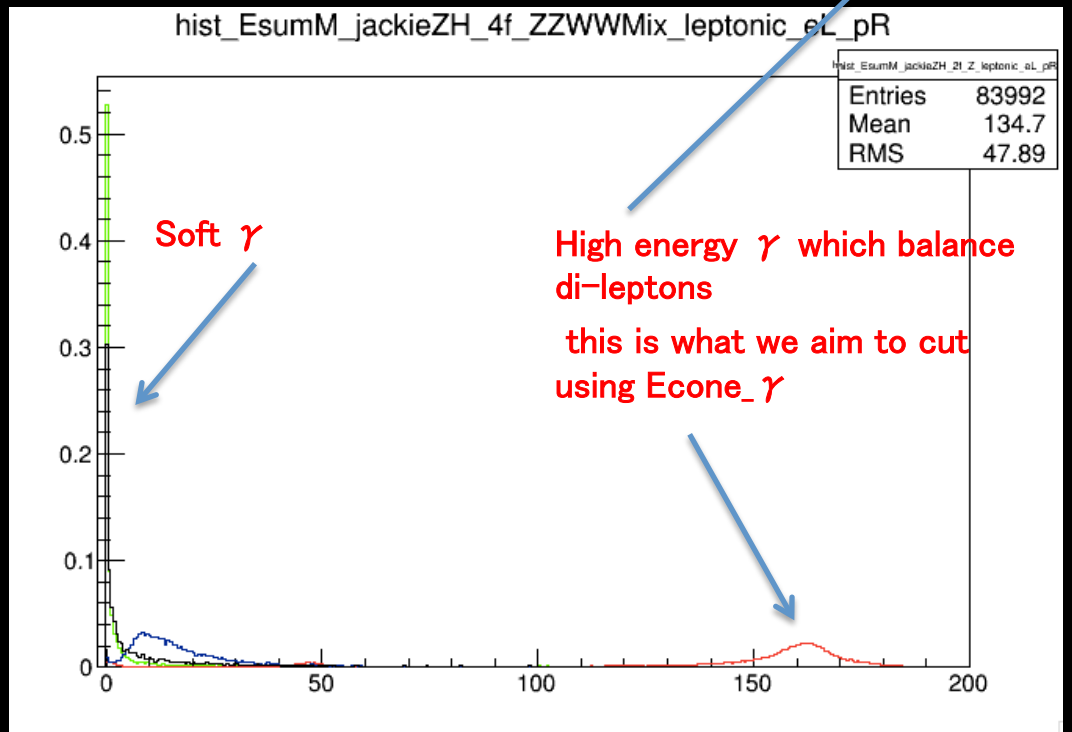
Ecm = 250 GeV


no. of events
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0.02
0.025
0.03
0.035
0.04
h1
Entries 10000
Mean 0.02916
RMS 0.000573
Δ σ / σ = 2.92 %
S/B ratio almost 100%

BACKUP



Before invariant mass cut and Pt cut



Just after invariant mass cut and Pt cut

2D distr. Of

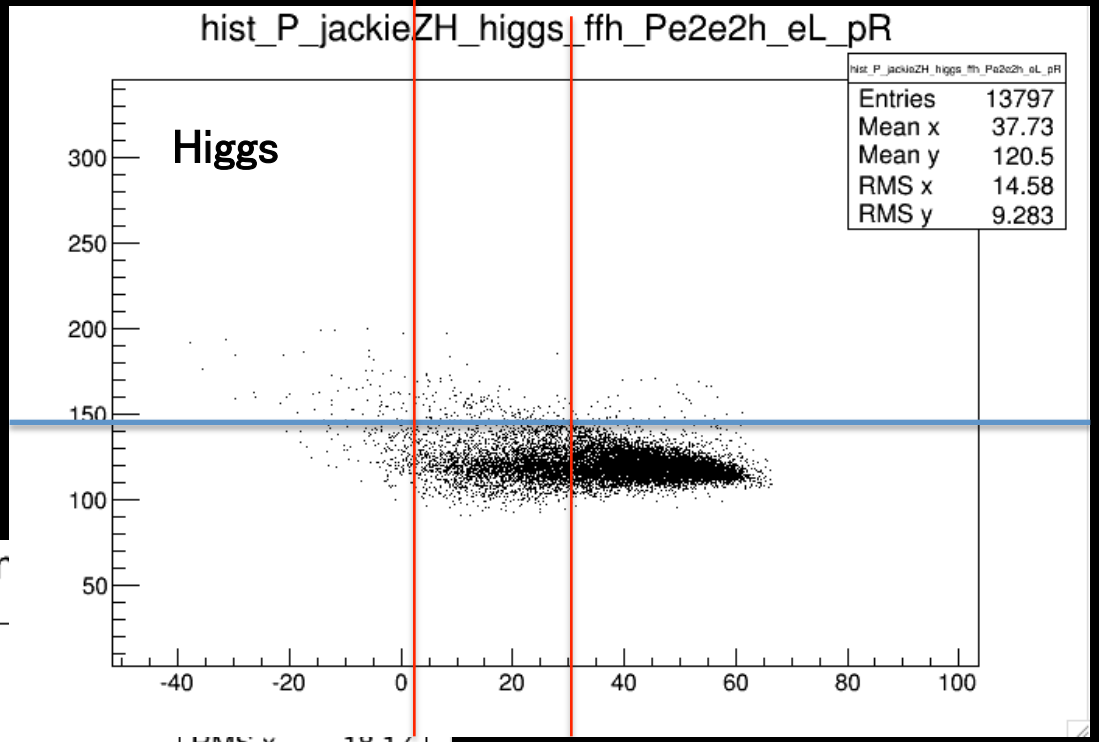
X: dptabl

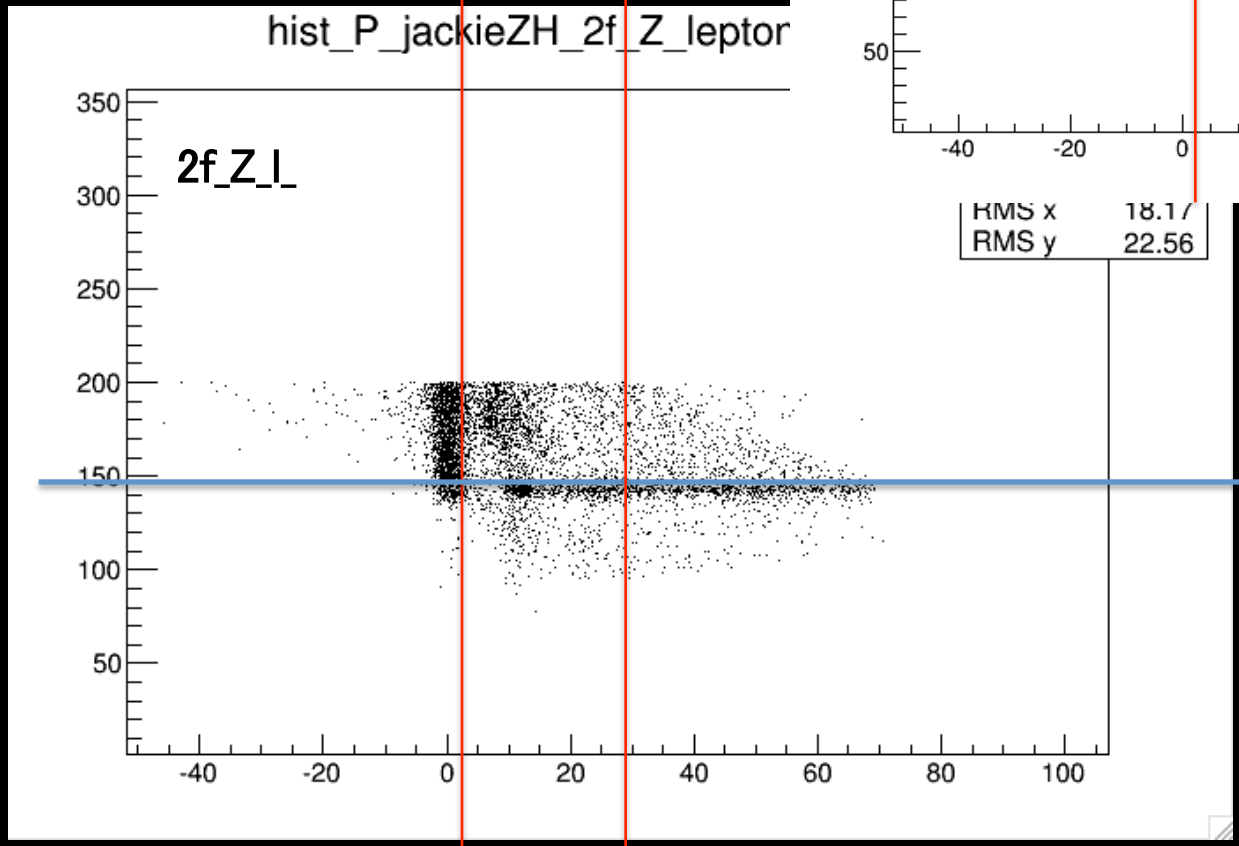
Y: Ebal = E γ + E_dl

Similar done for

X: Econe_γ

Y: Ebal





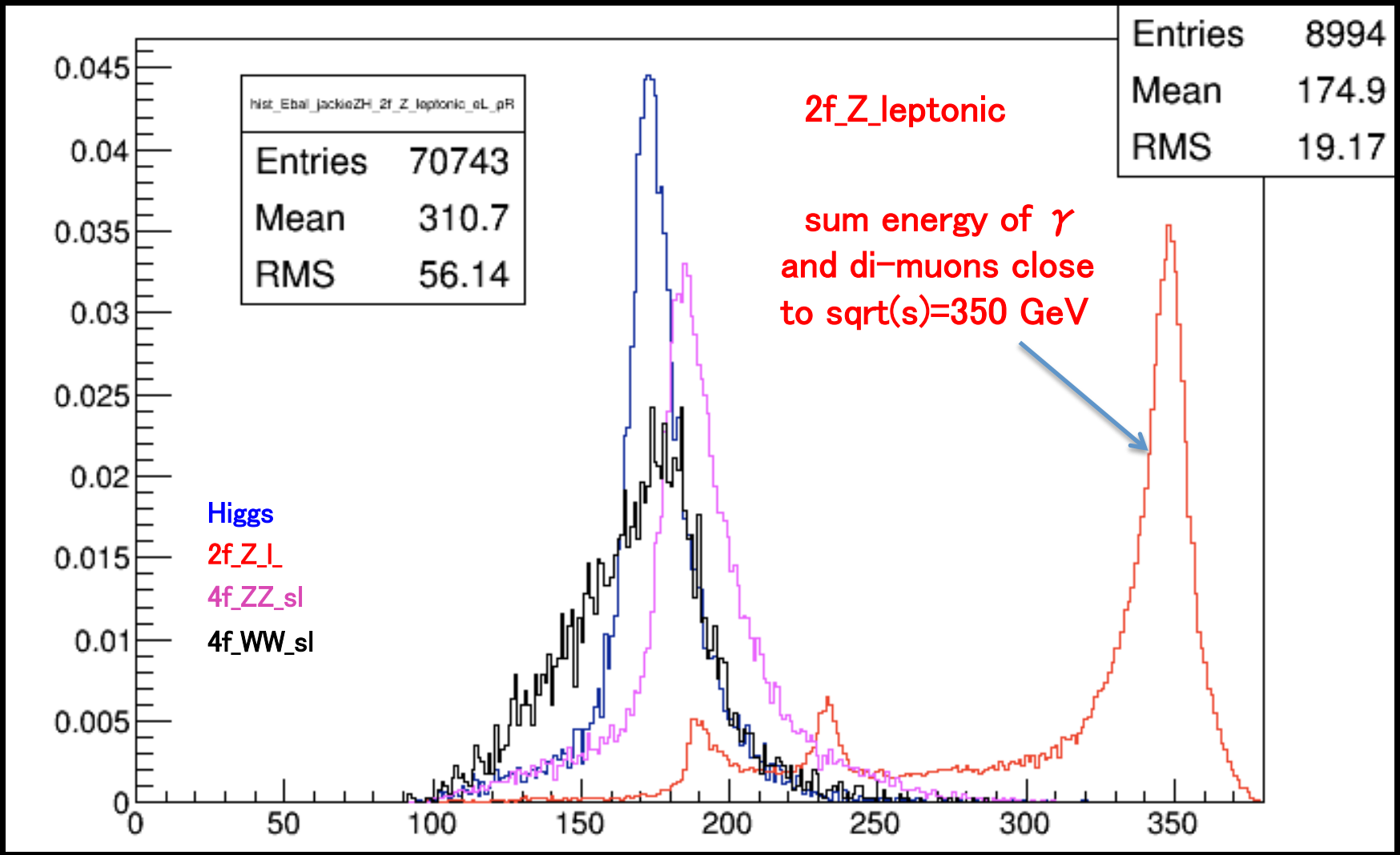
1. First cut everything dptbal < 5 GeV
2. Then cut (dptbal < 30 GeV && Ebal > 145 GeV)

ECM= 250 GeV

I applied a condition to prevent signal bias

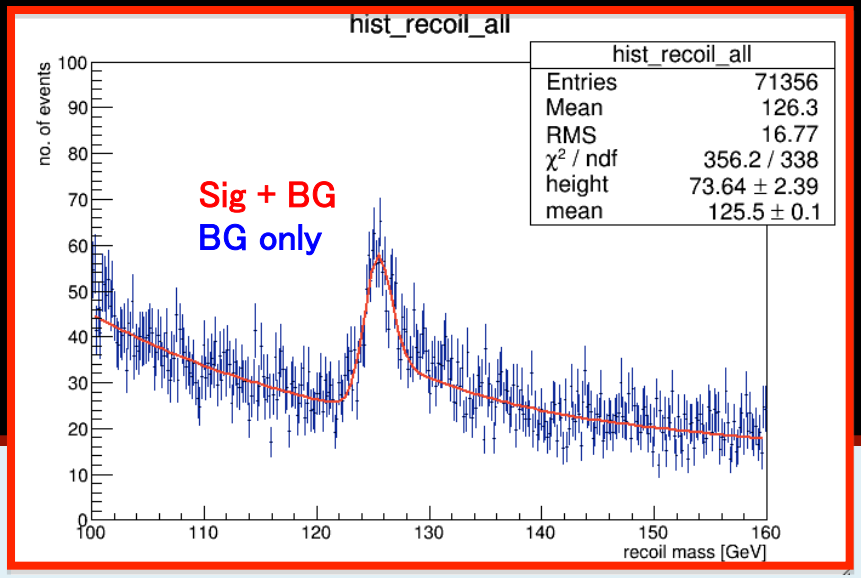
I required energy sum of γ and di-muon to be > 0.8 * sqrt(s)

signature of 2f_Z_leptonic BG



recoil mass fitting method

Fit range: 100–160 GeV



1st step:

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

2nd step :

fit Sig + BG : only float height and mean

fix others from step 1

◆ **SIGNAL: GPET:** 5 parameters :

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

Gaus (left-side) ,

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

Gaus + expo (right side)

Toy MC study

Toy MC 10000 seeds

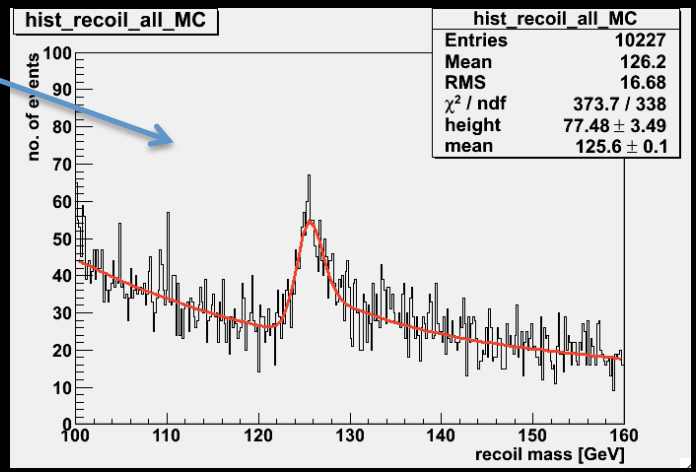
goal: test quality of fitting method

in terms of M_h、 xsec etc……

method:

generate MC events according to fittied “real” data (Poisson)

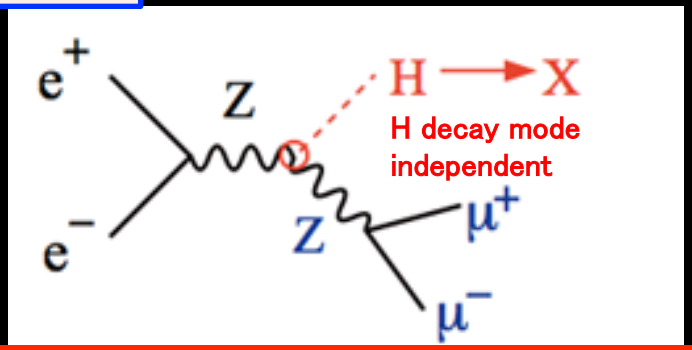
fit MC hist with same GPET function → get Nsig, xsec



ILC sample used in analysis

chanel	mh	ECM	L	Spin polarization	Detector simulation
e+e→Zh->μμh	125 GeV	350 GeV	333 fb-1	P(e-,e+) = (-0.8,+0.3) (+0.8,-0.3)	Full ILD (ILD_01_v05 DBD ver.)

signal Pe2e2h_.eL.pR / Pe2e2h._eR.pL



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

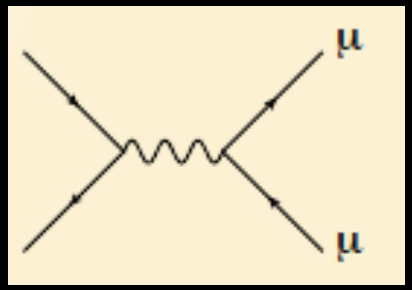
Higgs recoil against di-lepton (μ μ) system

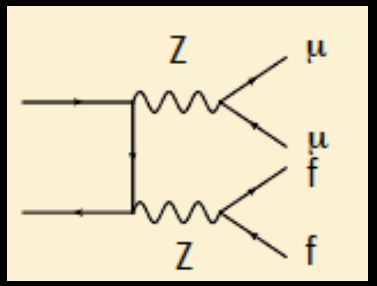
BG :

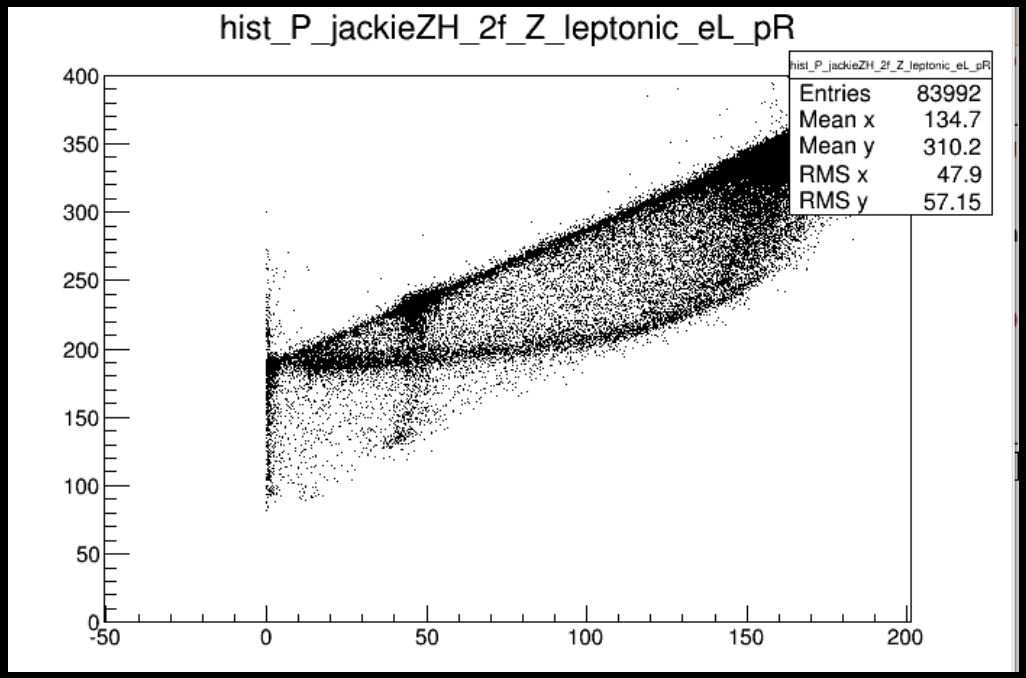
all 2f, 4f, 6f processes

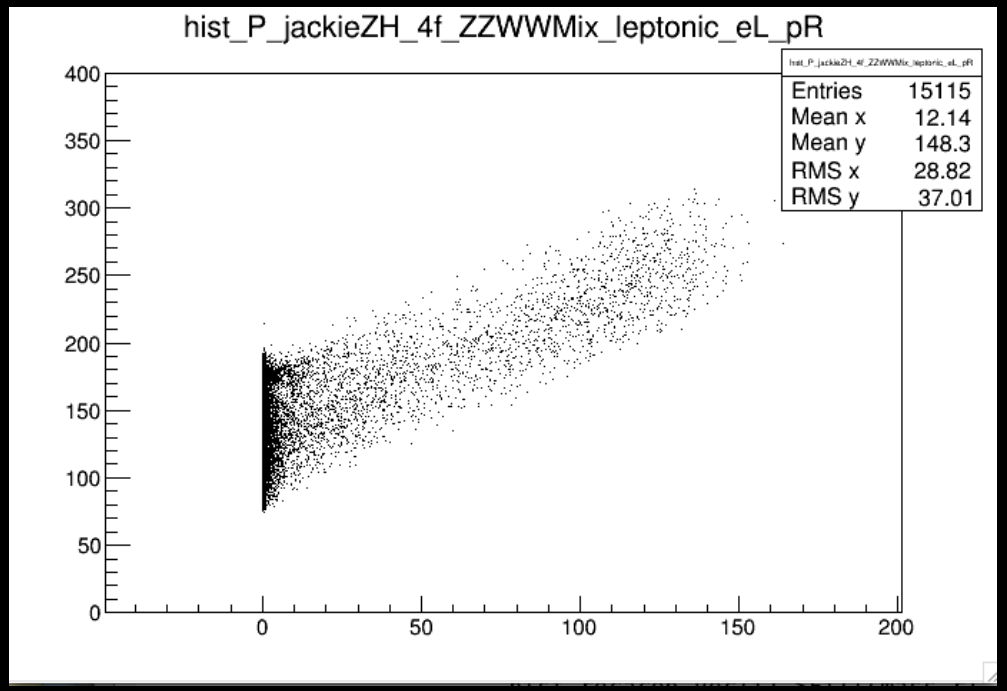
major BG after event selection:

2f_Z_l (μ μ), 4f_WWsl , 4f_ZZ_sl (μ μ ff, μ μ ν ν)









2D distr. Of

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