Z lineshape

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Introduction

- Formulate a data-taking scheme for the precise measurement of the properties of Z gauge boson.

- Aims to improve the precision of key parameters of Z boson and make good use of the performance of future colliders(CEPC).

What I have done

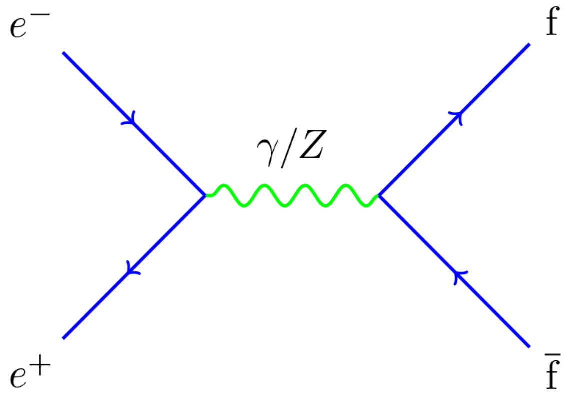
- ✓Basic formulae used to describe cross-sections and asymmetries at the Z resonance.
- ✓How to calculate radiative corrections(only ISR actually…)
- ✓Statistical uncertainty
- ✓Some systematic uncertainties($\sigma_E, \Delta E, \Delta\sigma_E, \Delta \int L$)
- ✓A preliminary data-taking scheme

What I have done

✓Basic formulae

- In lowest order and neglecting fermion masses the differential cross-section for the reaction can be written as:

$$\frac{2s}{\pi N_c}\frac{d\sigma_{ff}}{d\cos\theta}$$
$$= \alpha^2 Q_f^2(1+\cos^2\theta)$$
$$+ 8\,\mathrm{Re}\left\{\alpha Q_f \chi^*(s)\left[\, C^{s}_{\gamma Z}(1+\cos^2\theta) + 2C^{a}_{\gamma Z}\cos\theta \,\right]\right\}$$
$$+ 16|\chi(s)|^2\left[\, C^{s}_{ZZ}(1+\cos^2\theta) + 8C^{a}_{ZZ}\cos\theta \,\right]$$



with

$$\chi(s) = \frac{G_F \bar{m}_Z^2}{8\pi\sqrt{2}}\frac{s}{s-\bar{m}_Z^2 + i\bar{m}_Z\bar{\Gamma}_Z}$$

$$C^{s}_{\gamma Z} = \hat{g}_{Ve}\hat{g}_{Vf}, \qquad C^{a}_{\gamma Z} = \hat{g}_{Ae}\hat{g}_{Af},$$

$$C^{s}_{ZZ} = (\hat{g}^2_{Ve}+\hat{g}^2_{Ae})(\hat{g}^2_{Vf}+\hat{g}^2_{Af}), \qquad C^{a}_{ZZ} = \hat{g}_{Ve}\hat{g}_{Ae}\hat{g}_{Vf}\hat{g}_{Af}.$$

$$\hat{g}_{Af} = I^3_f,\, \hat{g}_{Vf} = I^3_f - 2Q_f\sin^2\theta_W$$

What I have done

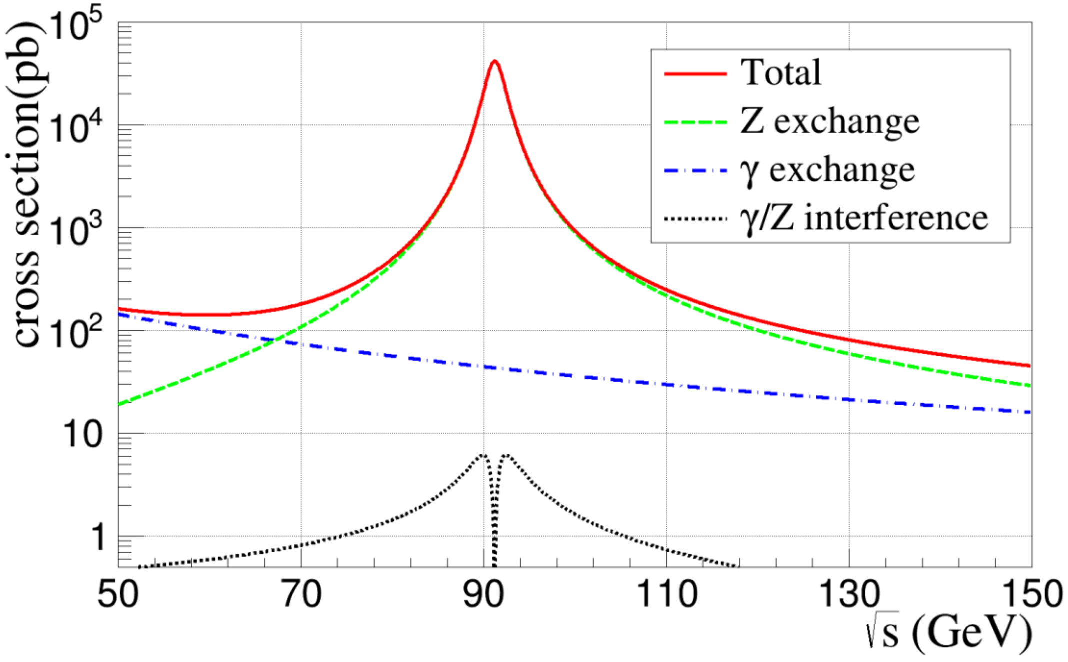
✓Basic formulae

- cross-section:

$$\sigma_{f\bar{f}} = \sigma^{\gamma}_{f\bar{f}} + \sigma^{\gamma/Z}_{f\bar{f}} + \sigma^{Z}_{f\bar{f}}$$
$$= \frac{4\pi\alpha^2(s)}{3s} Q_f^2 N_c$$
$$+ \frac{2\sqrt{2}\alpha(s)}{3}(Q_f G_F N_c \hat{g}_{Ve}\hat{g}_{Vf}) \frac{(s-m_Z^2)m_Z^2}{(s-m_Z^2)^2 + s^2\Gamma_Z^2/m_Z^2}$$
$$+ \sigma_f^0 \frac{s\Gamma_Z^2}{(s-m_Z^2)^2 + s^2\Gamma_Z^2/m_Z^2} \frac{1}{\delta_{QED}}$$

with

$$\sigma_f^0 = \frac{12\pi}{m_Z^2}\frac{\Gamma_{ee}\Gamma_{ff}}{\Gamma_Z^2} = \frac{C^s_{ZZ} N_c}{6\pi}\left(\frac{m_Z^2 G_F}{\Gamma_Z}\right)^2$$



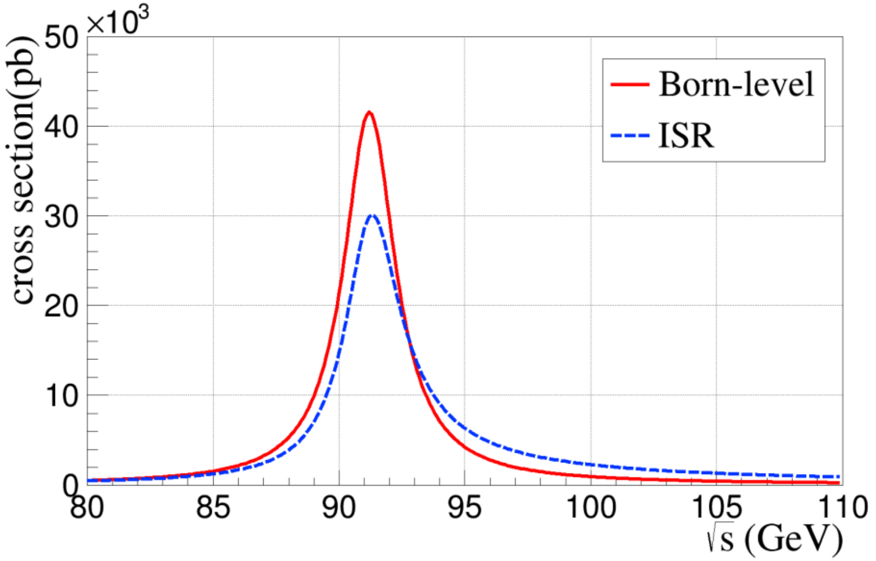
- Fit parameters M_Z Γ_Z σ^0_{had} C^s_{ZZ} C^a_{ZZ} $C^s_{\gamma Z}$ $C^a_{\gamma Z}$

What I have done

✓ISR

$$\sigma_{\mathrm{f\bar{f}}}^{\mathrm{obs}}(s) = \int_0^{1-s_m/s} dx\sigma(s(1-x))F(x,s)$$

$$F(x,s) = \beta x^{\beta-1}\delta^{V+S} + \delta^{H}$$



What I have done

✓Statistical uncertainty

✓Some systematic uncertainties($\sigma_E, \Delta E, \Delta\sigma_E, \Delta \int L$)

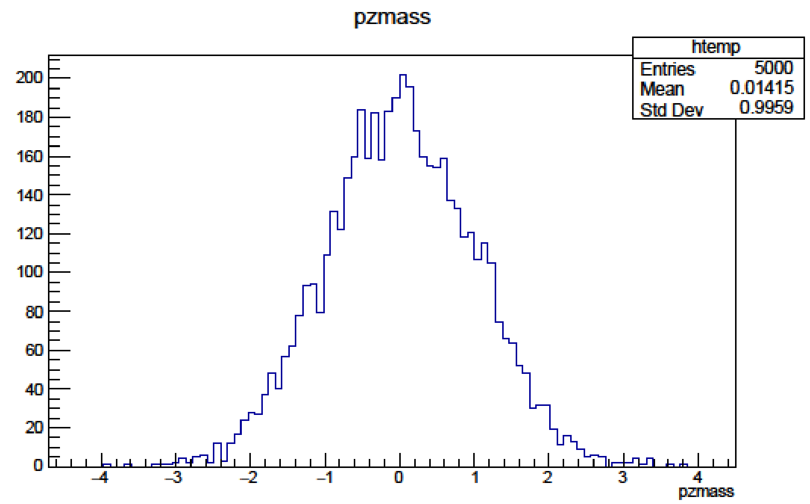
✓A preliminary data-taking scheme

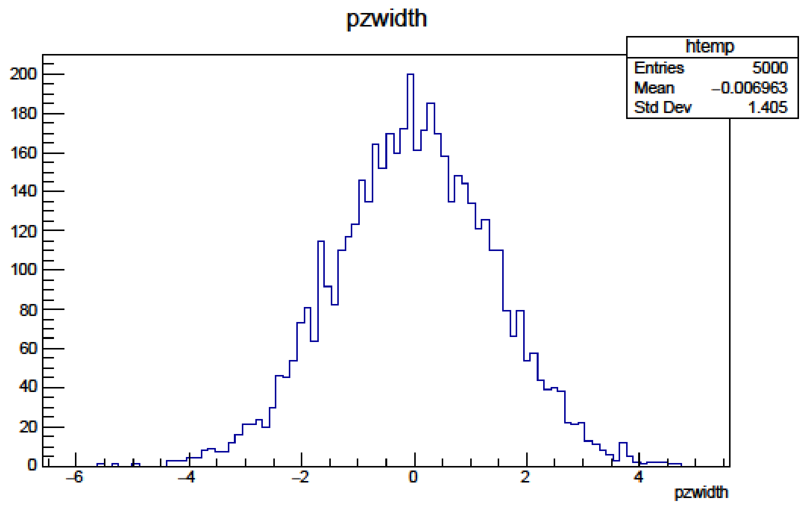
$\sqrt{s}$ (GeV)	$\mathcal{L}$ (ab^{-1})	$\sqrt{s}$ (GeV)	$\mathcal{L}$ (ab^{-1})	$\sqrt{s}$ (GeV)	$\mathcal{L}$(ab^{-1})
$E_1 = 84.6$	$\mathcal{L}_1 = 0.09$	$E_6 = 90.4$	$\mathcal{L}_6 = 0.50$	$E_{10} = 93.2$	$\mathcal{L}_{10} = 0.25$
$E_2 = 85.6$	$\mathcal{L}_2 = 0.13$	$E_7 = 91.2$	$\mathcal{L}_7 = 5.00$	$E_{11} = 94.3$	$\mathcal{L}_{11} = 0.18$
$E_3 = 87.9$	$\mathcal{L}_3 = 0.18$	$E_8 = 92.0$	$\mathcal{L}_8 = 0.50$	$E_{12} = 95.3$	$\mathcal{L}_{12} = 0.13$
$E_4 = 88.7$	$\mathcal{L}_4 = 0.25$	$E_9 = 92.5$	$\mathcal{L}_9 = 0.35$	$E_{13} = 96.2$	$\mathcal{L}_{13} = 0.09$
$E_5 = 89.9$	$\mathcal{L}_5 = 0.35$				

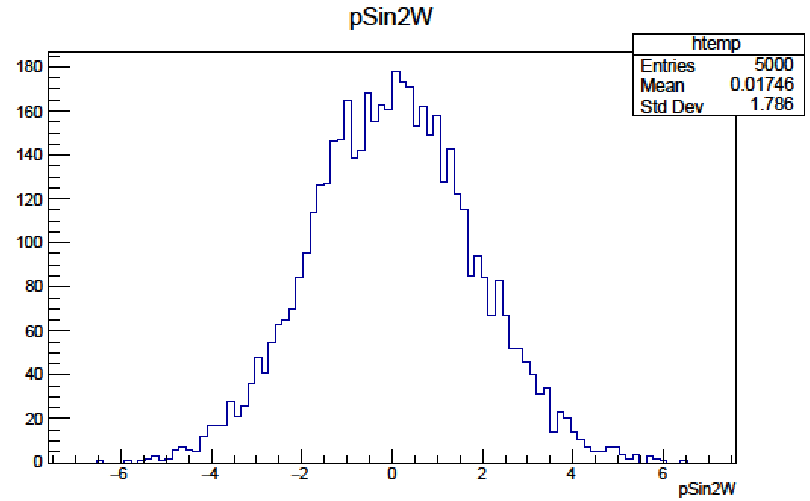
参数	δ_{stat}	δ_{total}
M_Z (KeV)	7	66
Γ_Z (KeV)	13	126
σ^0_{had} (pb)	0.09	1.73

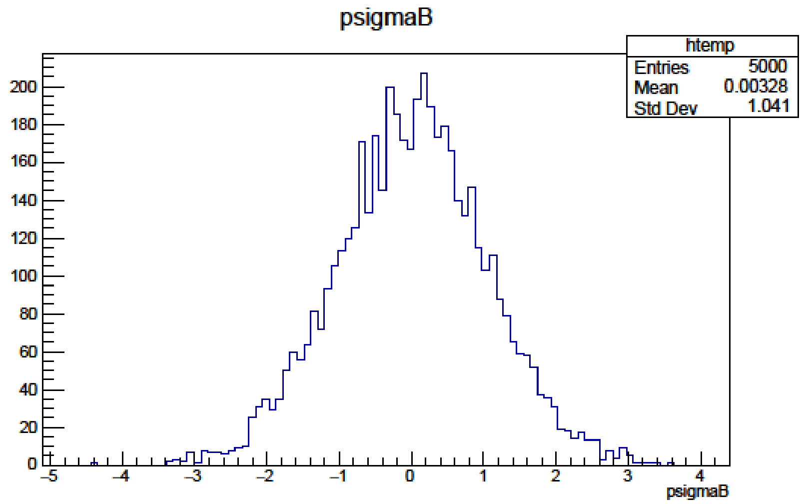
What I am doing

- Change fit parameters to : $M_{\mathrm{Z}}\ \Gamma_{\mathrm{Z}}\ \sigma^{0}_{\mathrm{had}}\ \sin^{2}\theta_{W}$



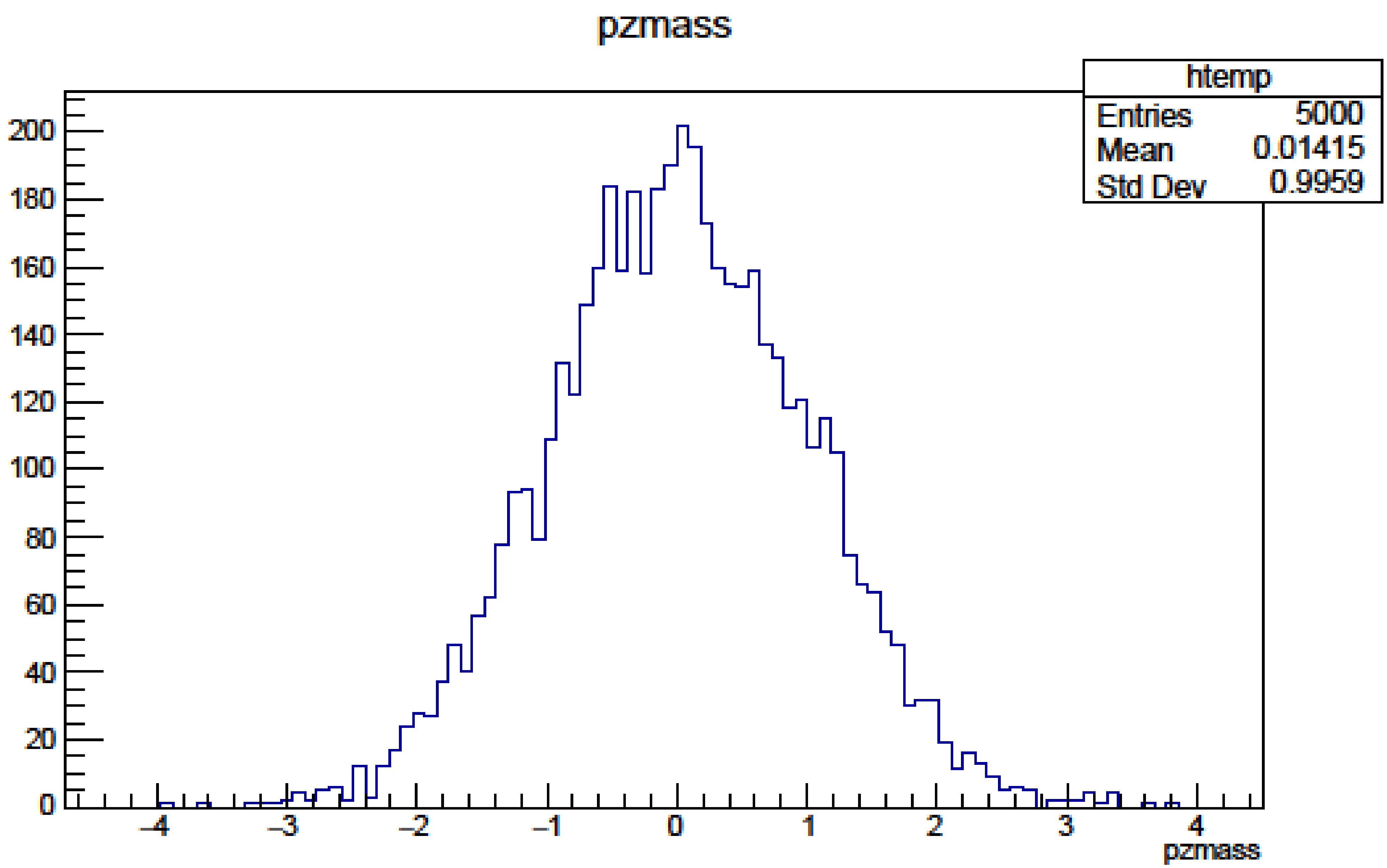


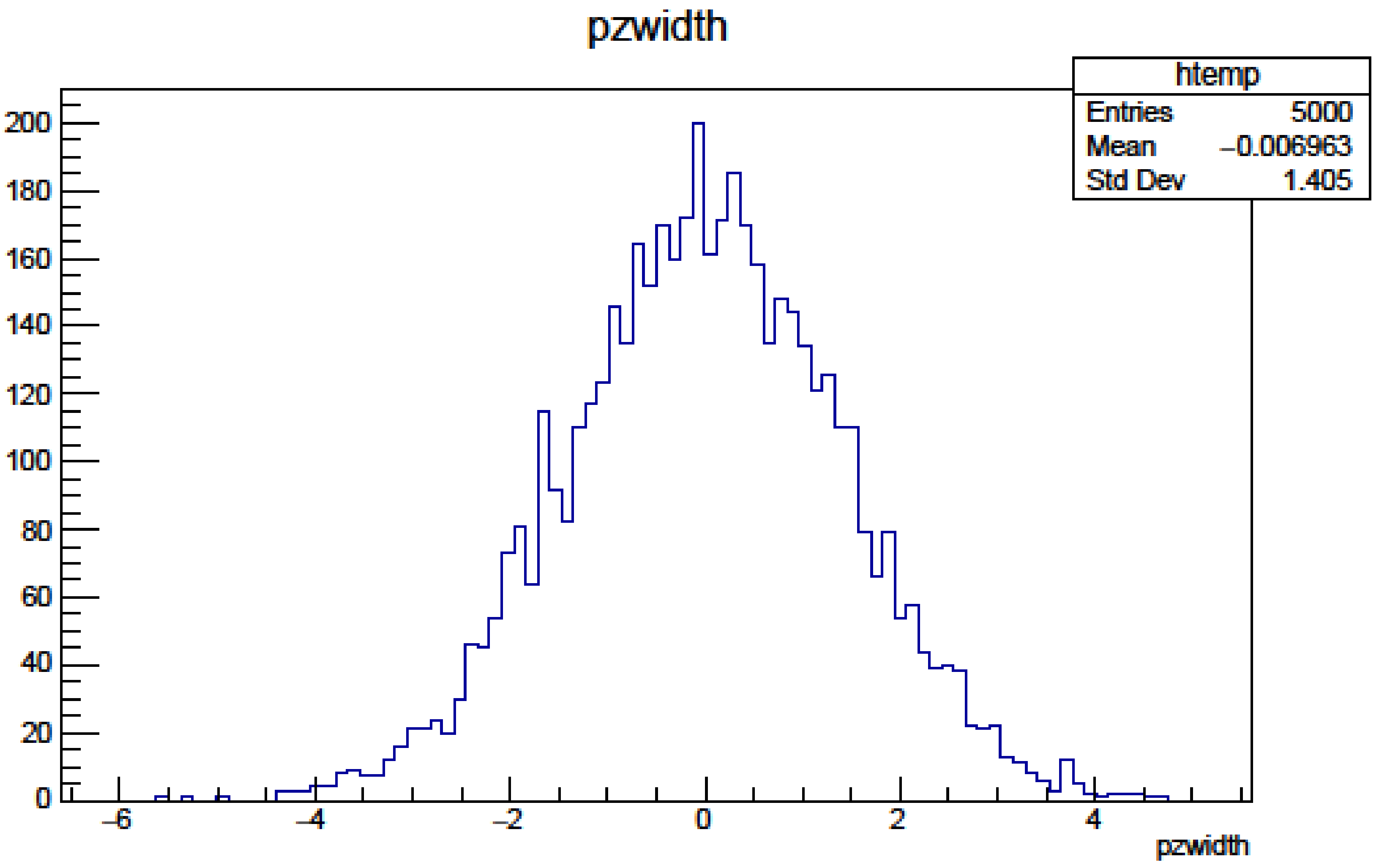




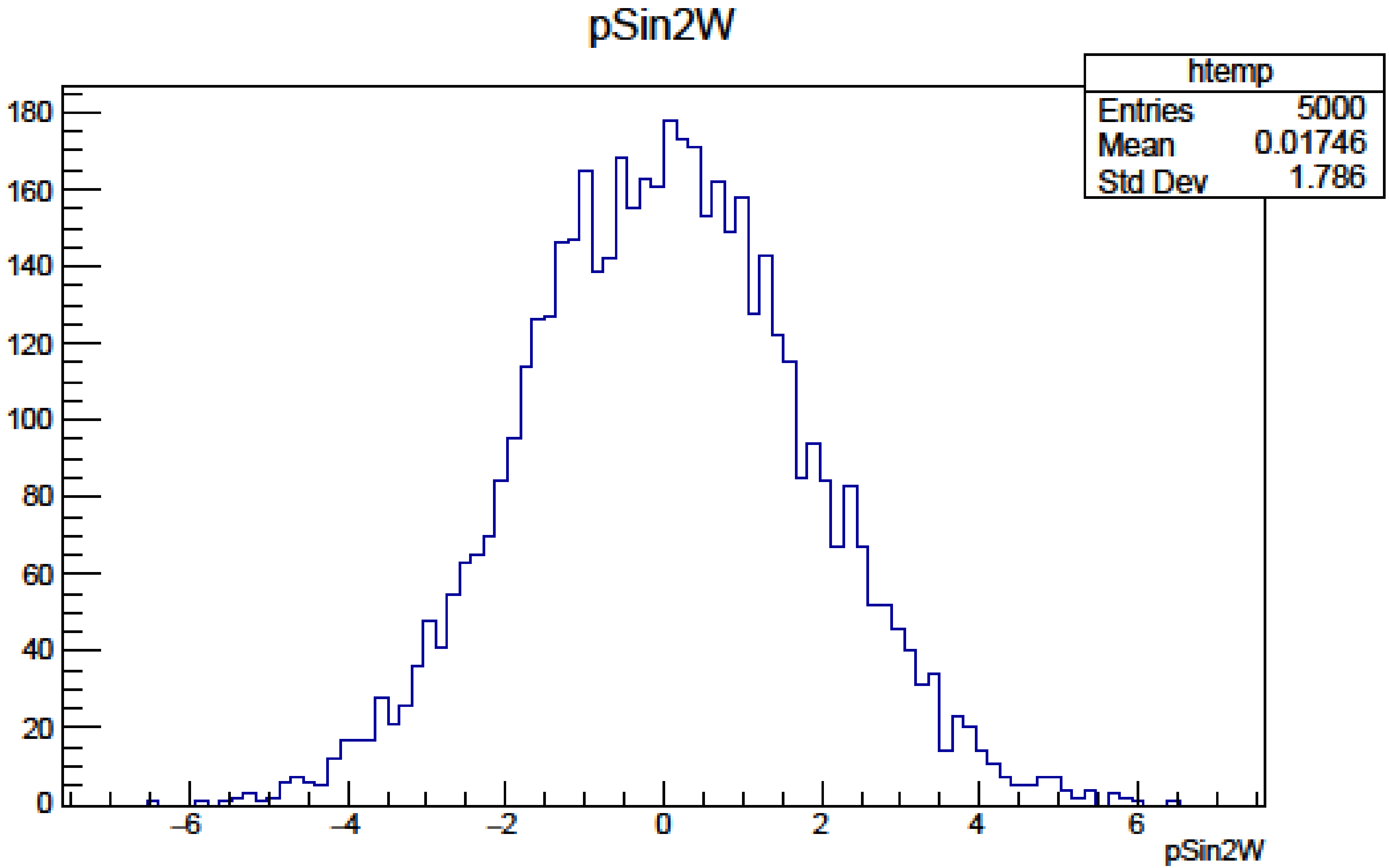
PARAMETER CORRELATION COEFFICIENTS

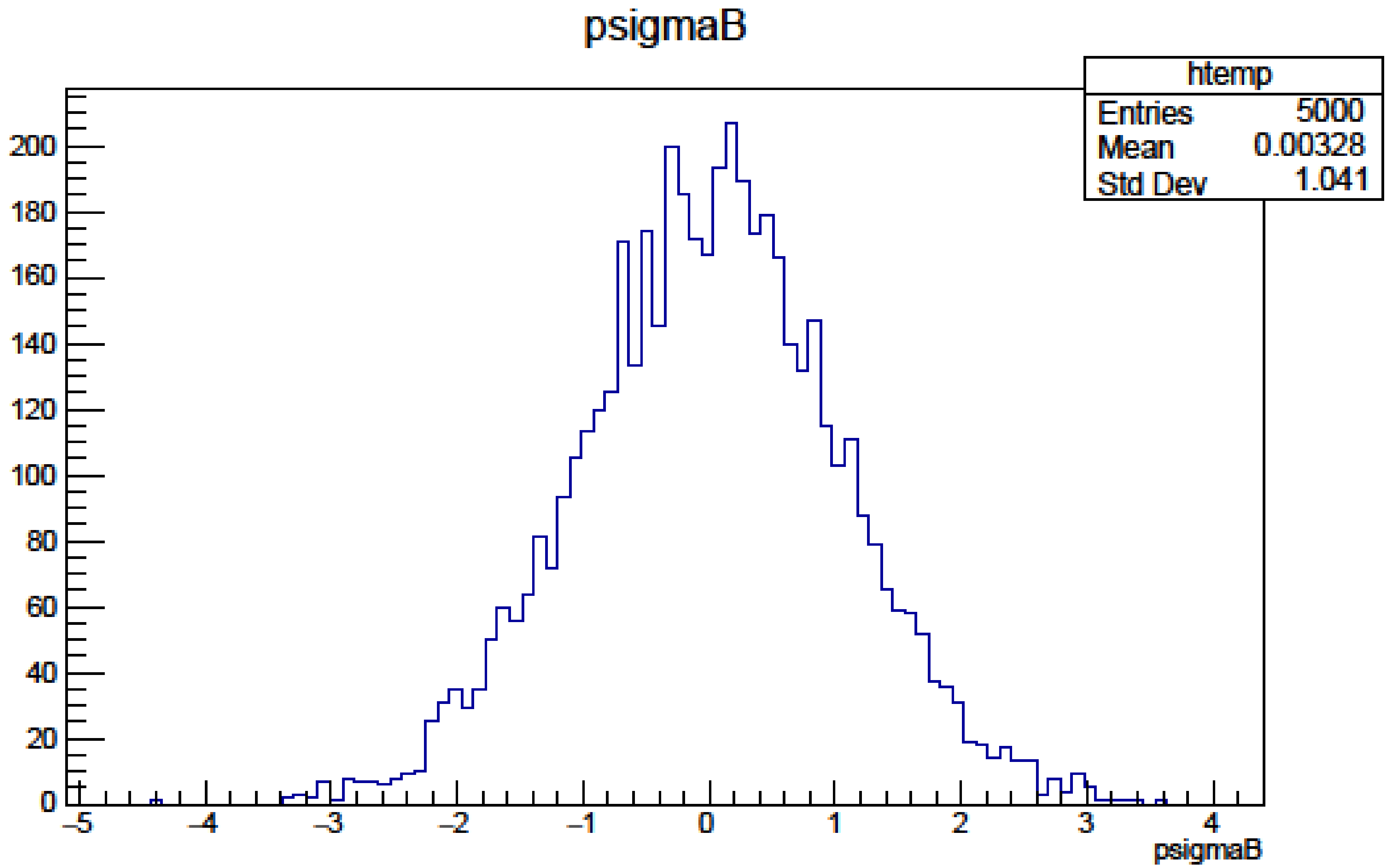
NO.	GLOBAL	1	2	3	4
1	0.10916	1.000	0.055	-0.002	-0.107
2	0.42468	0.055	1.000	-0.274	-0.349
3	0.27389	-0.002	-0.274	1.000	0.094
4	0.35941	-0.107	-0.349	0.094	1.000


pzmass
htemp
Entries 5000
Mean 0.01415
Std Dev 0.9959
0
20
40
60
80
100
120
140
160
180
200
−4
−3
−2
−1
0
1
2
3
4
pzmass



pzwidth
htemp
Entries 5000
Mean −0.006963
Std Dev 1.405
200
180
160
140
120
100
80
60
40
20
0
−6
−4
−2
0
2
4
pzwidth


pSin2W
htemp
Entries 5000
Mean 0.01746
Std Dev 1.786
180
160
140
120
100
80
60
40
20
0
−6
−4
−2
0
2
4
6
pSin2W


psigmaB
htemp
Entries 5000
Mean 0.00328
Std Dev 1.041
200
180
160
140
120
100
80
60
40
20
0
−5
−4
−3
−2
−1
0
1
2
3
4
psigmaB