STCF实验$Y(4230)\to\pi^{\pm}Z_c^{\mp}(3900)$的模拟研究

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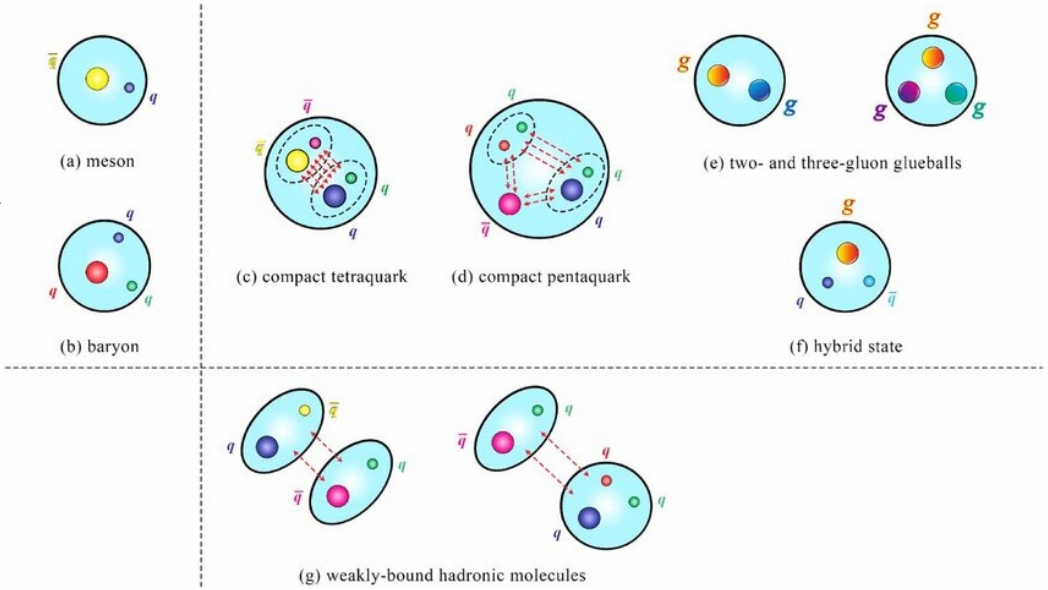
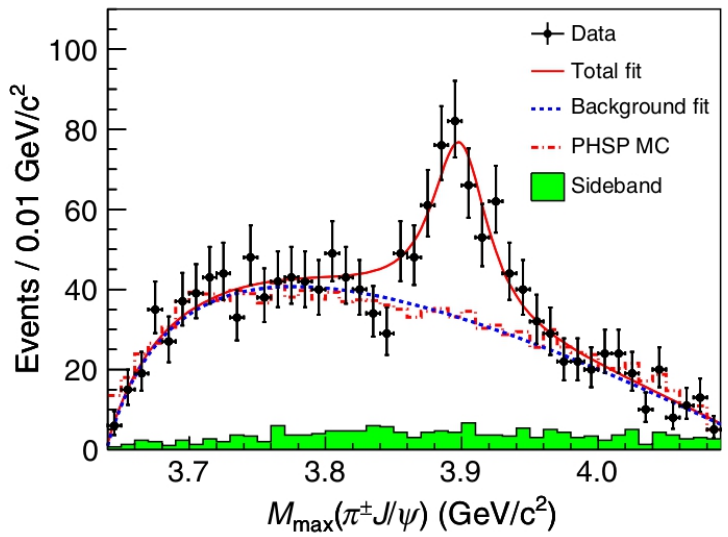
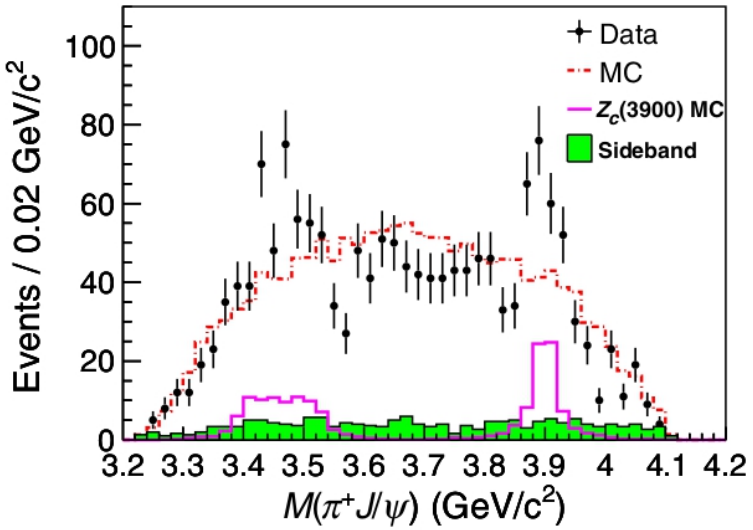
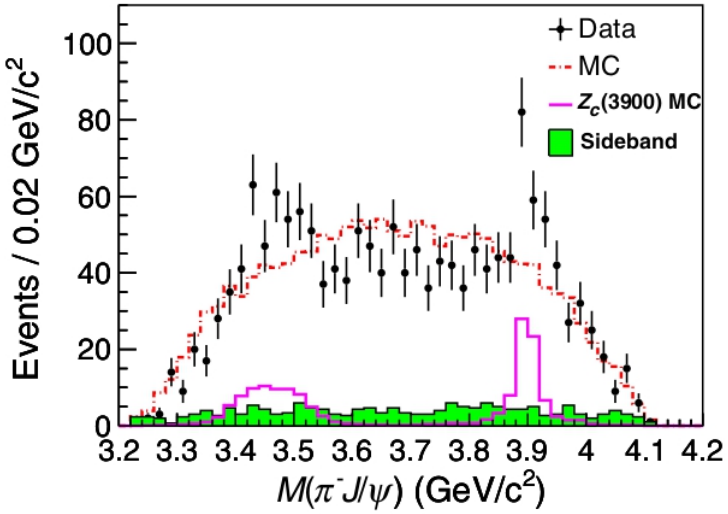
XYZ粒子

- 奇特强子态：不能被传统夸克模型描述的奇特态粒子
- 自2003年$X(3872)$发现以来，许多新的奇特态粒子候选者被发现
  - Y：量子态为J^{PC}=1--的矢量态
  - Z：带电的同位旋多重态，含有粲夸克的称为Z_c
  - X：其他具有奇特性质的同位旋标量粒子
- Z_c：可能的四夸克态或者强子分子态









DIY产生子

For the cascade decay, the amplitude is just the multiplication of the amplitude of each step. For the decay process $Y \to Z_c^{\pm}\pi^{\mp}, Z_c^{\pm} \to \pi^{\pm}J/\psi, J/\psi \to \ell^+\ell^-$, the helicity amplitude is:

$$A_{Z_c}(\lambda_Y, \lambda_{Z_c}, \lambda_{\ell^+}, \lambda_{\ell^-}) = F^{J_Y}_{\lambda_{Z_c},0} D^{J_Y}_{\lambda_Y,\lambda_{Z_c}}(\theta_{Z_c}, \phi_{Z_c}) \cdot BW(Z_c) \cdot F^{J_{Z_c}}_{\lambda_{J/\psi},0} D^{J_{Z_c}}_{\lambda_{Z_c},\lambda_{J/\psi}}(\theta_{J/\psi}, \phi_{J/\psi}) \cdot F^{J_{J/\psi}}_{\lambda_{\ell^+},\lambda_{\ell^-}} D^{J_{J/\psi}}_{\lambda_{J/\psi},\lambda_{\ell^+}-\lambda_{\ell^-}}(\theta_{\ell^+}, \phi_{\ell^+}), \quad (4)$$

For decay process $Y \to R_f J/\psi, R_f \to \pi^+\pi^-, J/\psi \to \ell^+\ell^-$, where R_f is the resonance decays into $\pi^+\pi^-$, the helicity amplitude is:

$$A_{R_f}(\lambda_Y, \lambda_{R_f}, \lambda_{\ell^+}, \lambda_{\ell^-}) = F^{J_Y}_{\lambda_{R_f},\lambda_{J/\psi}} D^{J_Y}_{\lambda_Y,\lambda_{R_f}-\lambda_{J/\psi}}(\theta_{R_f}, \phi_{R_f}) \cdot BW(R_f) \cdot F^{J_{R_f}}_{0,0} D^{J_{R_f}}_{\lambda_{R_f},0}(\theta_{\pi^+}, \phi_{\pi^+}) \cdot F^{J_{J/\psi}}_{\lambda_{\ell^+},\lambda_{\ell^-}} D^{J_{J/\psi}}_{\lambda_{J/\psi},\lambda_{\ell^+}-\lambda_{\ell^-}}(\theta_{\ell^+}, \phi_{\ell^+}), \quad (5)$$

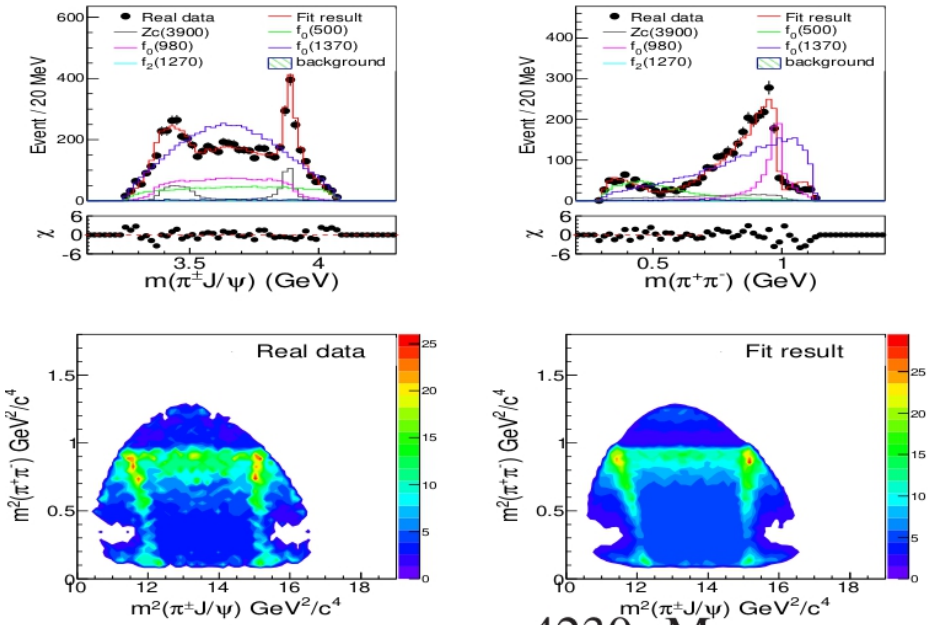
where λ_{Z_c}, λ_{R_f}, $\lambda_{J/\psi}$, λ_{ℓ^+}, λ_{ℓ^-} denote helicities for the $Z_c^{\pm}$, R_f, J/ψ, ℓ^+ and ℓ^-, respectively. (θ_j, ϕ_j) (j stands for $Z_c^{\pm}$, R_f, J/ψ, $\pi^{\pm}$ and $\ell^{\pm}$) are the (polar, azimuthal) angles of the momentum vector of $Z_c^{\pm}$, R_f, J/ψ, $\pi^{\pm}$ and $\ell^{\pm}$ in the helicity system of $Y(4260)$, $Z_c^{\pm}$, R_f and J/ψ, respectively. J_Y, J_{Z_c}, J_{R_f} and $J_{J/\psi}$ are the spin of their corresponding mother particle ($Y(4260)$, $Z_c^{\pm}$, R_f and J/ψ). $BW(Z_c)$ and $BW(R_f)$ are the propagator functions for resonances Z_c and R_f. The helicity-coupling amplitudes $F^X_{\lambda_m,\lambda_n}$ is calculated using Eq. 3.

The possible resonances R_f that decay into $\pi^+\pi^-$ are $f_0(500)(\sigma)$, $f_0(980)$, $f_2(1270)$, and $f_0(1370)$. The central values of the mass for $f_2(1270)$ and $f_0(1370)$ are out of the kinematic region for $Y(4260) \to \pi^+\pi^- J/\psi$, but their broad widths allow them to decays into $\pi^+\pi^-$ in their low mass tails.

- 螺旋度方法构建振幅，参数来自BESIII分波分析
- 两种情况

$$Y \to Z_c^{\pm}\pi^{\mp}, Z_c^{\pm} \to \pi^{\pm}J/\psi, J/\psi \to \ell^+\ell^-$$
$$Y \to R_f J/\psi, R_f \to \pi^+\pi^-, J/\psi \to \ell^+\ell^-$$

- R_f可能为$f_0(500), f_0(980), f_2(1270), f_0(1370)$



4230: Mass

memo
https://docbes3.ihep.ac.cn/DocDB/0010/001075/045/PiZc.pdf

DIY产生子


```
detalg.property("mDIY").set(True)
decaymode = ["Zcp_SS",
    "Zcp_SD",
    "Zcp_DS",
    "Zcp_DD",
    "Zcm_SS",
    "Zcm_SD",
    "Zcm_DS",
    "Zcm_DD",
    "f0500_SS",
    "f0500_DS",
    "f0980_SS",
    "f0980_DS",
    "f01370_SS",
    "f01370_DS",
    "f21270"]
detalg.property("AmpTerm").set(decaymode)
decaypar =[-30.72943,  2.903876,-0.9671876, -17.
detalg.property("AmpPara").set(decaypar)
#****************** EvtGen
```

```
detalg0 = task.createAlg("KKMC")
detalg0.property("CMSEnergy").set(4.23)
```

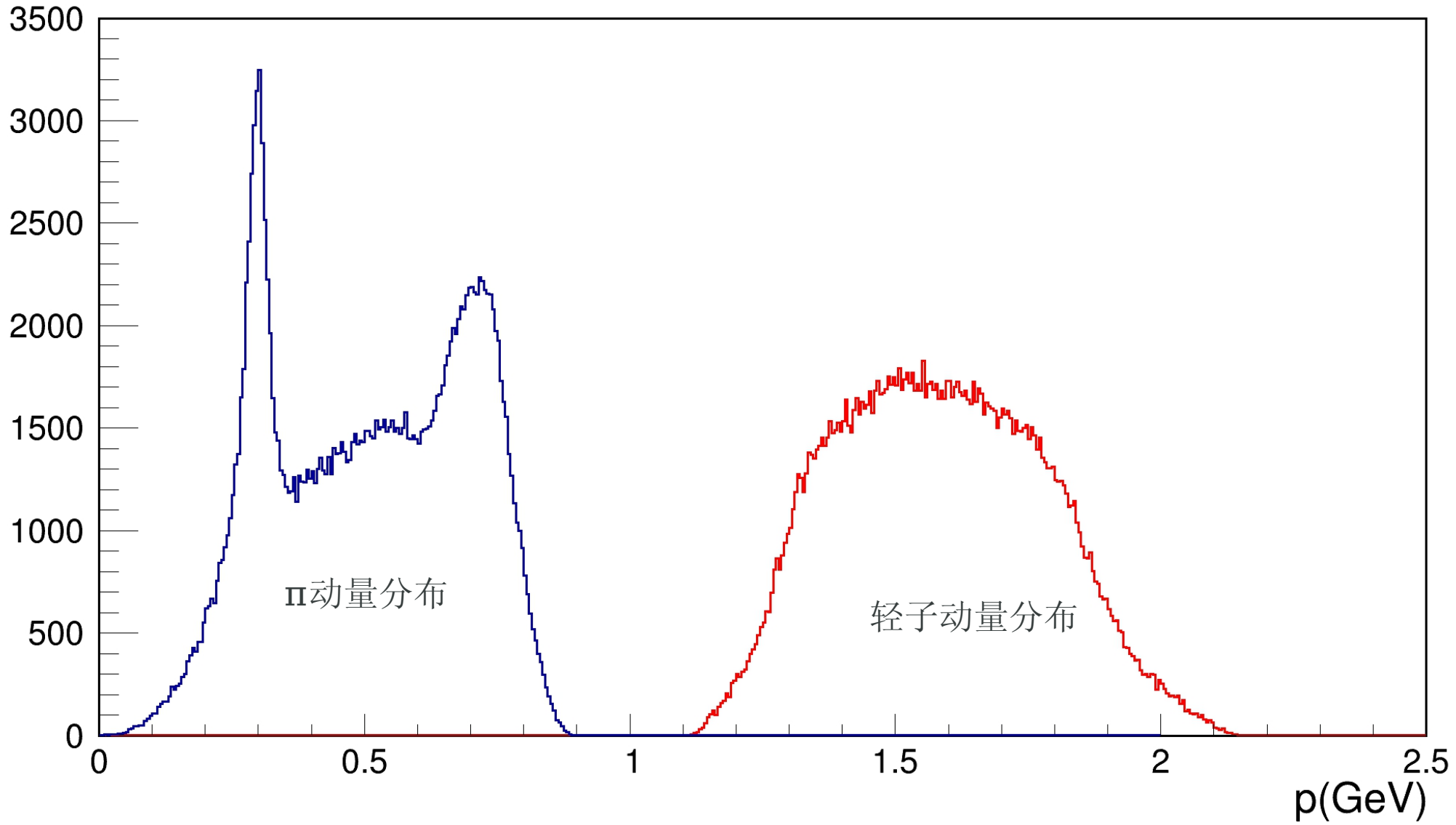
```
detalg0.property("GeneratePsi4260").set(True)
```

KKMC产生Y，$\sqrt{s} = 4.23GeV$

```
noPhotos

Decay psi(4260)
1.000    pi+ pi- J/psi                    PHSP;
Enddecay

Decay J/psi
0.0594   e+  e-                                PHSP;
0.0593   mu+  mu-                              PHSP;
Enddecay

End
```

mDIY产生子代码来自李旭红

Truth分布


3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
p(GeV)
π动量分布
轻子动量分布

事例选择条件

Charged tracks

- $|d_0| < 1.0\ cm$ && $|d_z| < 10.0\ cm$;
- $N_{positive} >= 2$ && $N_{negative} >= 2$.

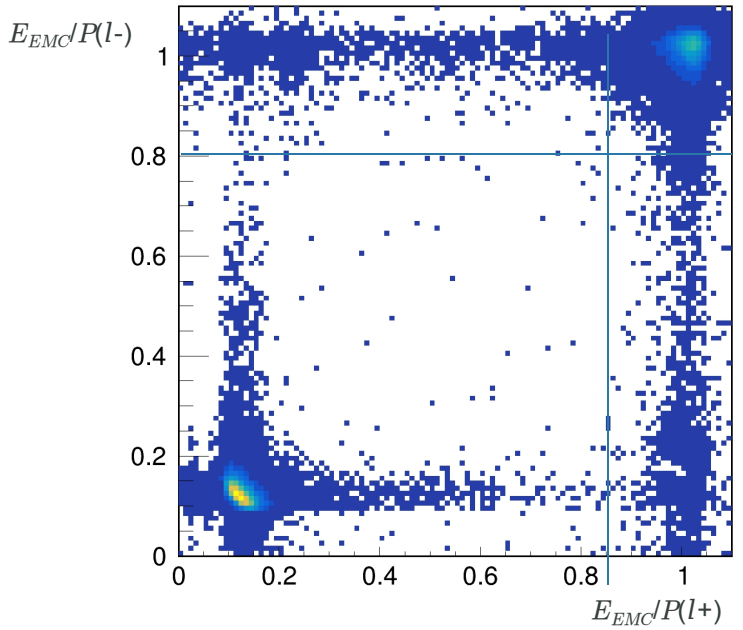
PID

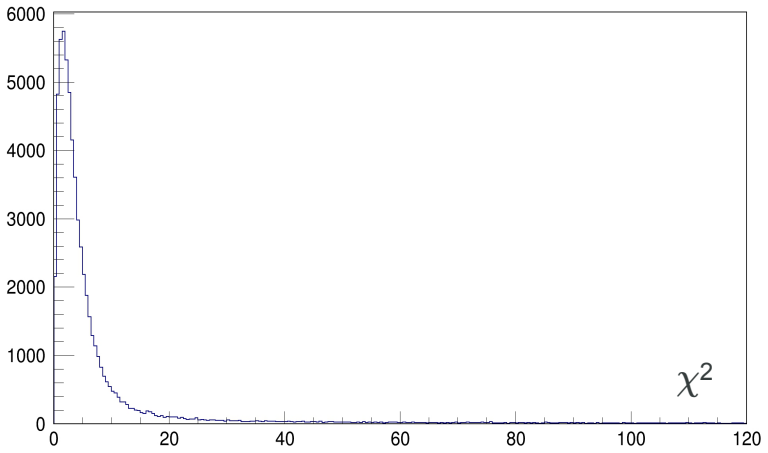
- $p_\pi < 1\ GeV/c$, $p_l > 1\ GeV/c$;
- $N_{\pi-} >= 1$&& $N_{\pi+} >= 1$&& $N_{l+} >= 1$&& $N_{l-} >= 1$.
- *Electron*: $E_{EMC}/P > 0.8$
- *Muon*: $E_{EMC}/P < 0.8$

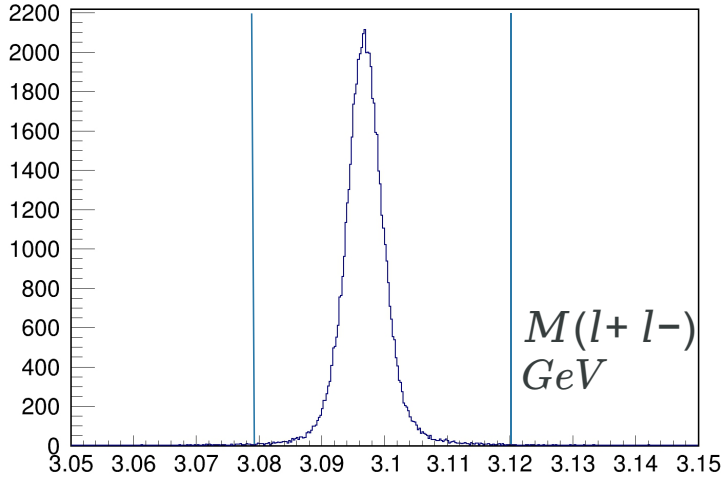
Kinematic Fit

- *four-momentum constraint*, $chi_{4c}^2 < 60$
- $3.08\ GeV/c^2 < M(l+\ l-) < 3.12\ GeV/c^2$

如果事例中存在多个满足如果条件的组合
取运动学拟合χ^2最小的一组



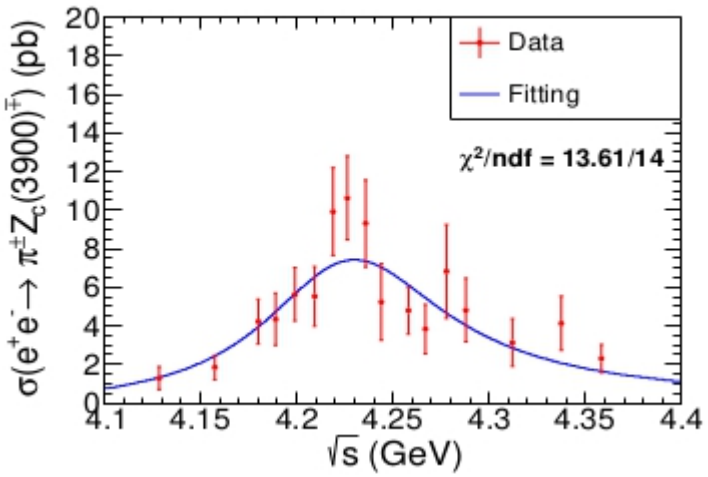




结果

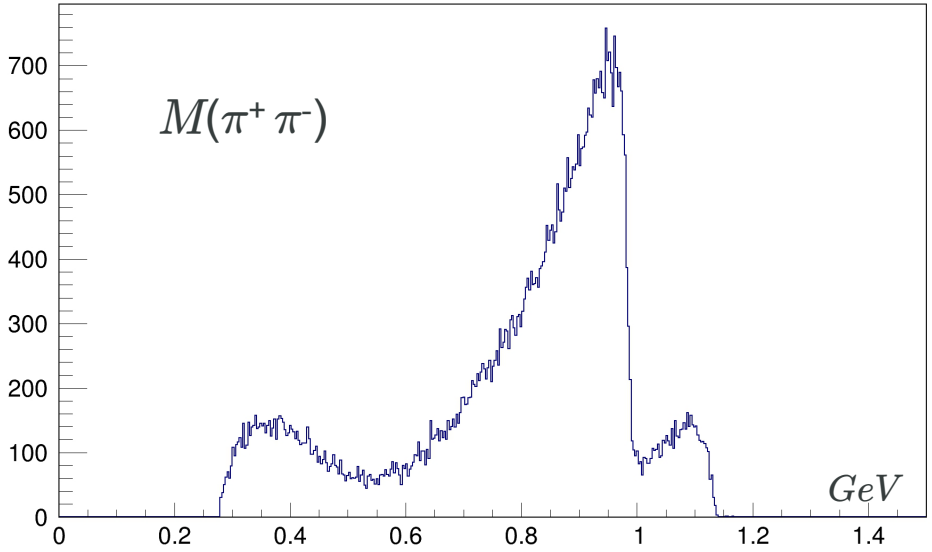
选择效率（未添加束流本底）10w事例

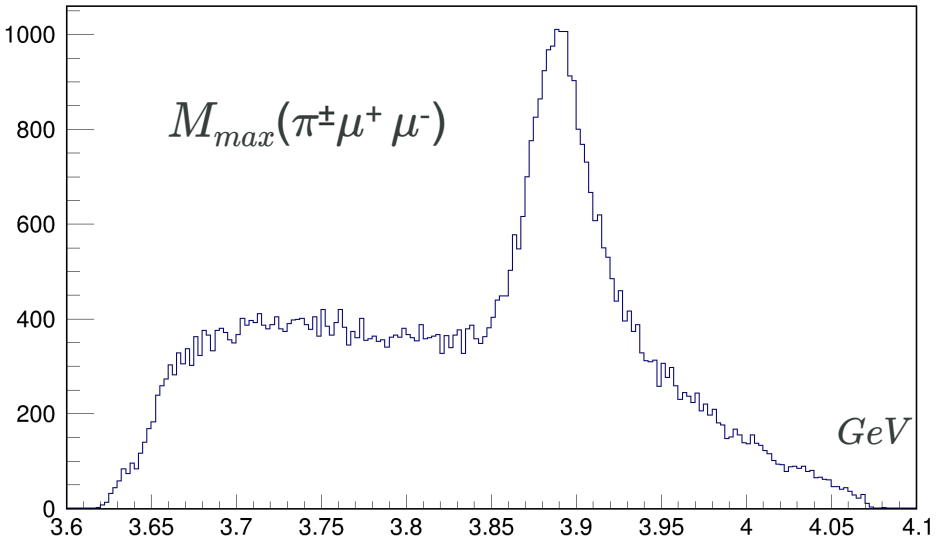
Cut Flow	Eff(%)	Rel.Eff(%)
$N_{pos} >= 2$, $N_{neg} >= 2$	72.45	72.45
$N_{\pi-} >= 1$ && $N_{\pi+} >= 1$ && $N_{l+} >= 1$ && $N_{l-} >= 1$	71.03	98.04
$\pi^+\pi^-$ l+l- assignment	69.35	97.63
$chi_{4c}^2 < 60$	61.68	88.94
Mass Window	61.27	99.39



BESIII测量截面

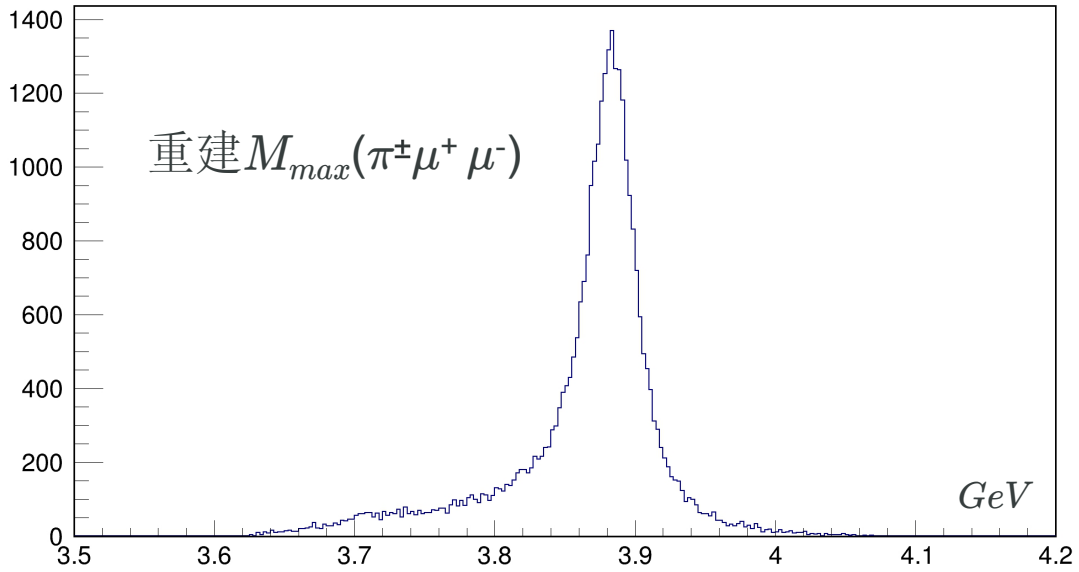
若在$\sqrt{s} = 4.23GeV$
积分亮度为100fb^{-1}
可收集～60w个
$\pi^{\pm}Z_c^{\mp}(3900)$事例

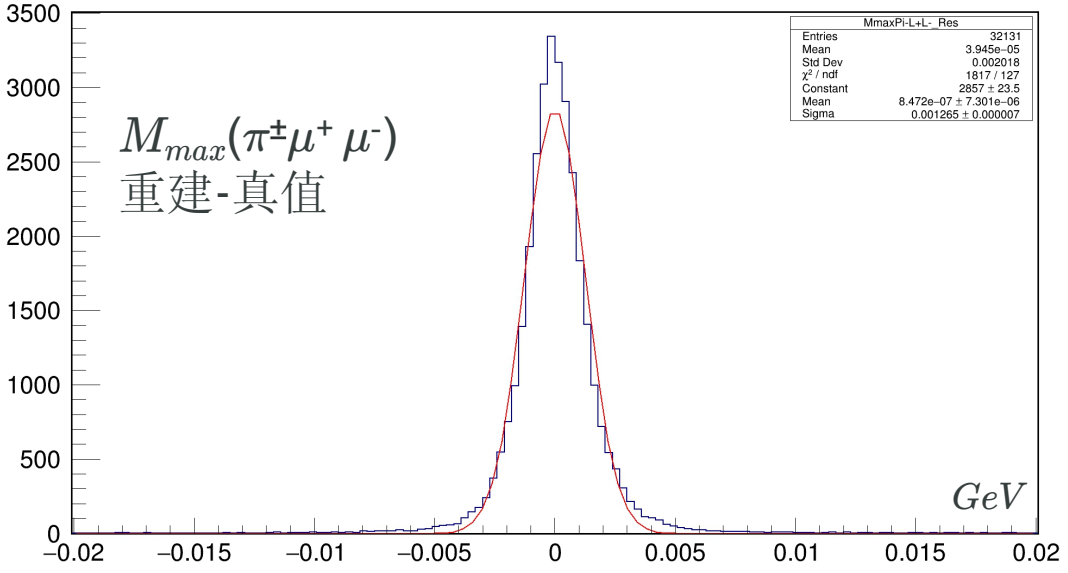




结果

只模拟$e^+e^- \to \pi^\pm Z_c^\mp$





BACK UP