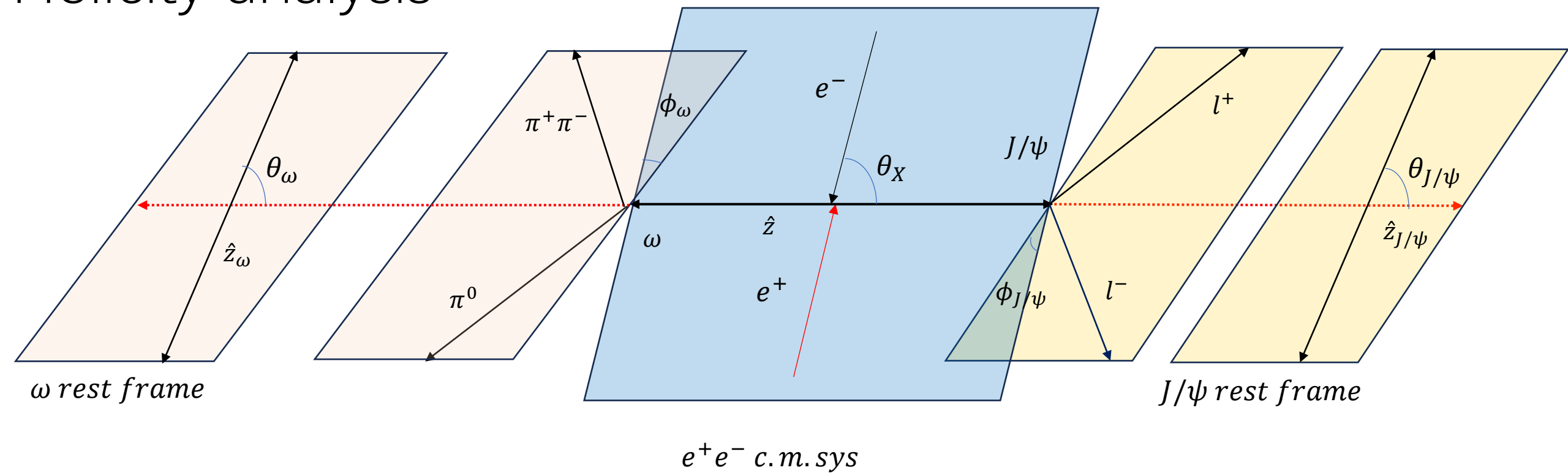


# Group meeting

2026/01/16

# Helicity analysis



- $\theta_X$ :  $e^+e^-$  质心系下  $J/\psi$  与  $z$  轴的极角。
- $\phi_{J/\psi}(\phi_\omega)$ :  $J/\psi(\omega)$  产生平面与衰变平面的夹角。
- $\theta_{J/\psi}$ :  $J/\psi$  质心系下  $l$  与  $z$  轴的极角。
- $\theta_\omega$ :  $\omega$  质心系下衰变平面的法向量与  $z$  轴的夹角。

# Fitting model

$$\ln \mathcal{L}(\vec{\theta}; \tau_k) = \sum_{k=1}^N w_k \ln \mathcal{I}(\tau_k; \vec{\theta})$$

2+ 下的角分布

$$\mathcal{A}_{\Lambda, \Delta\lambda_e} = \sum_{\lambda_1, \lambda_2} D_{\Lambda, \lambda_1 - \lambda_2}^{2*}(\phi_X, \theta_X, 0) \cdot H_{\lambda_1, \lambda_2} \cdot D_{\lambda_1, \Delta\lambda_e}^{1*}(\phi_{J/\psi}, \theta_{J/\psi}, 0) \cdot D_{\lambda_2, 0}^{1*}(\phi_\omega, \theta_\omega, 0)$$

$$I(\Omega) = \sum_{\Delta\lambda_e = \pm 1} [\rho_{22} (|\mathcal{A}_{+2, \Delta\lambda_e}|^2 + |\mathcal{A}_{-2, \Delta\lambda_e}|^2) + \rho_{00} |\mathcal{A}_{0, \Delta\lambda_e}|^2]$$



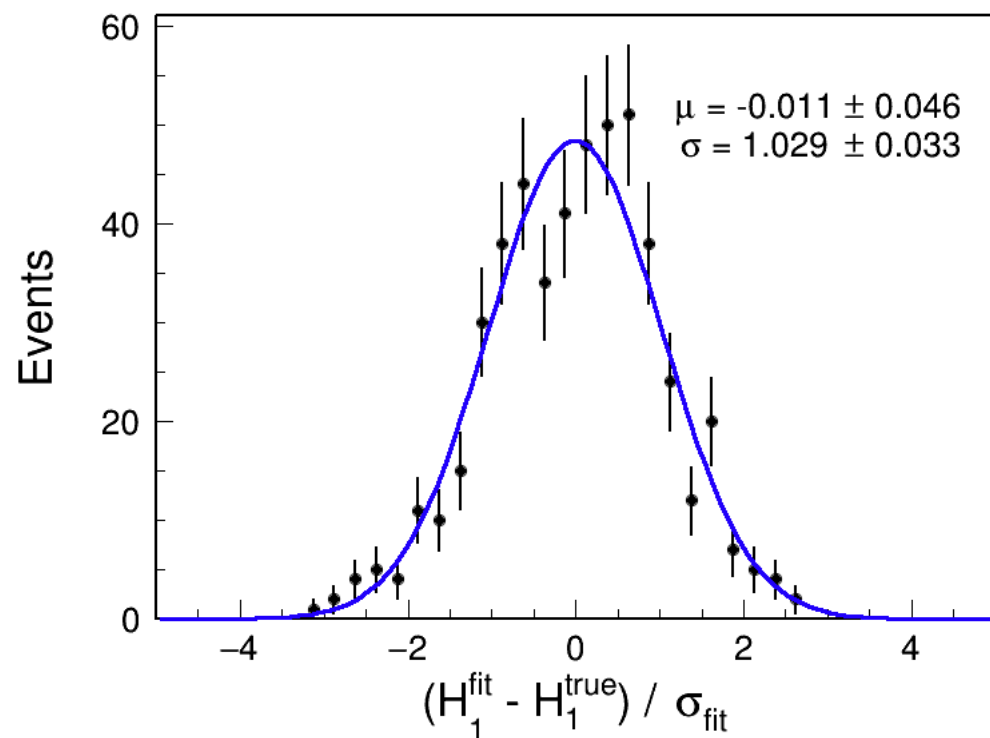
# Solve

相空间蒙卡归一：1M蒙卡

$$\ln \mathcal{L}(\vec{\theta}; \tau_k) = \sum_{k=1}^N w_k \ln \mathcal{I}(\tau_k; \vec{\theta}) - N \ln \left[ \frac{1}{N_{MC}} \sum_{j=1}^{N_{MC}^{acc}} \mathcal{I}(\tau_j; \vec{\theta}) \right],$$

得到的是振幅的相对强度 (H1/H2)

实数域检验：H1=0.6, H2=1



# 公式延申虚数域

H1, H2 代表的是不同子粒子螺旋度振幅间的相对强度与相位, 物理意义不直观, 转换到L-S表象 (不同分波)



$J^P$	$P(-1)^J$	$\mathcal{A}_{L_X S_X}^X$	Free parameters
$0^+$	+1	$S_0, D_2$	2
$0^-$	-1	$P_1$	0
$2^+$	+1	$S_2, D_0, D_1, D_2, G_2$	9
$2^-$	-1	$P_1, P_2, F_1, F_2$	7
$3^+$	-1	$D_1, D_2, G_1, G_2$	7
$4^+$	+1	$D_2, G_0, G_1, G_2, I_2$	9
$4^-$	-1	$F_1, F_2, H_1, H_2$	7

**Partial wave notation :  $L_S$**   
L = 0(S), 1(P), 2(D), 3(F), 4(G),  
5(H), 6(I)  
S = 0, 1, 2

Fit parameters:

- ▶ A complex coefficient for every partial-wave amplitude  $\mathcal{A}_{L_X S_X}^X$ . For a selected "anchor" amplitude it is set to 1.

# 公式延申虚数域

H1, H2 代表的是不同子粒子螺旋度振幅间的相对强度与相位, 物理意义不直观, 转换到L-S表象 (不同分波) 得到最终公式

$$\mathcal{A}_{\Lambda, \Delta\lambda_e} = \sum_{\lambda_1, \lambda_2} D_{\Lambda, \lambda_1 - \lambda_2}^{2*}(\phi_X, \theta_X, 0) \cdot H_{\lambda_1, \lambda_2} \cdot D_{\lambda_1, \Delta\lambda_e}^{1*}(\phi_{J/\psi}, \theta_{J/\psi}, 0) \cdot D_{\lambda_2, 0}^{1*}(\phi_\omega, \theta_\omega, 0)$$

$$H_{\lambda_1, \lambda_2} = \sum_{L, S} \sqrt{\frac{2L+1}{2J+1}} \langle L, 0; S, \lambda | J, \lambda \rangle \langle s_1, \lambda_1; s_2, -\lambda_2 | S, \lambda \rangle A_{L, S}$$

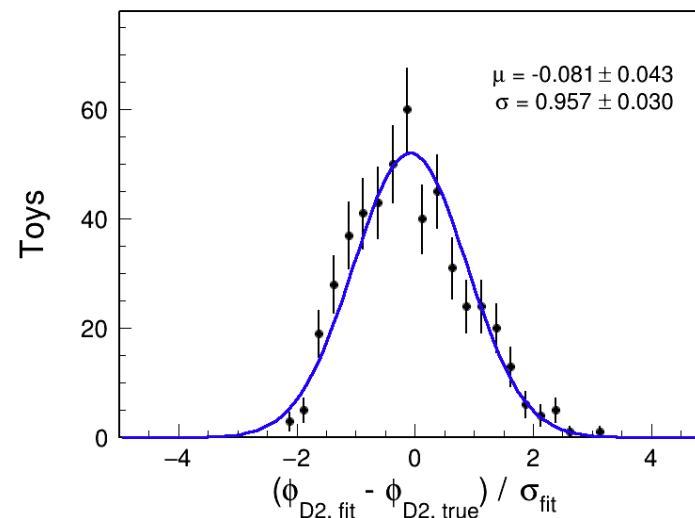
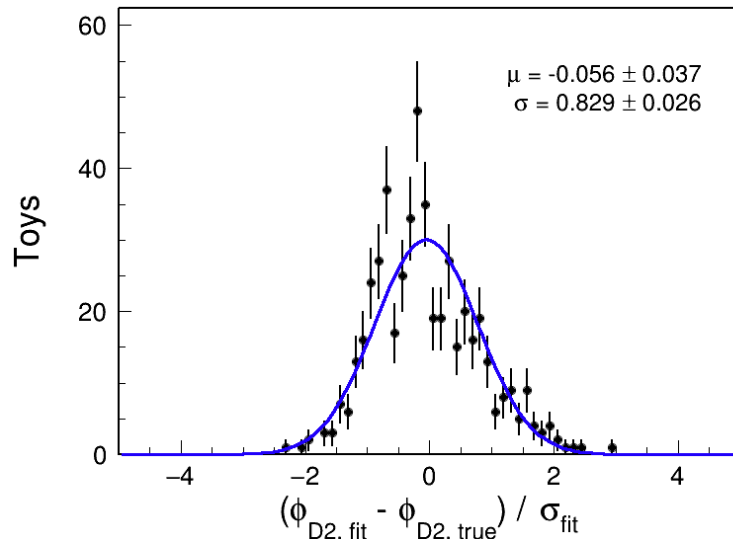
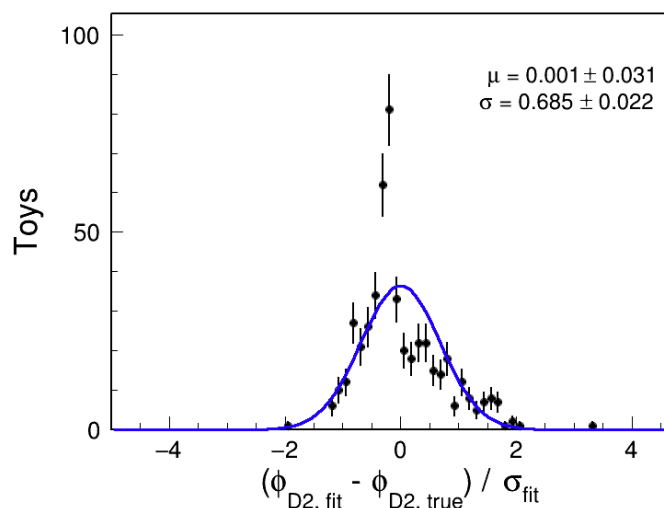
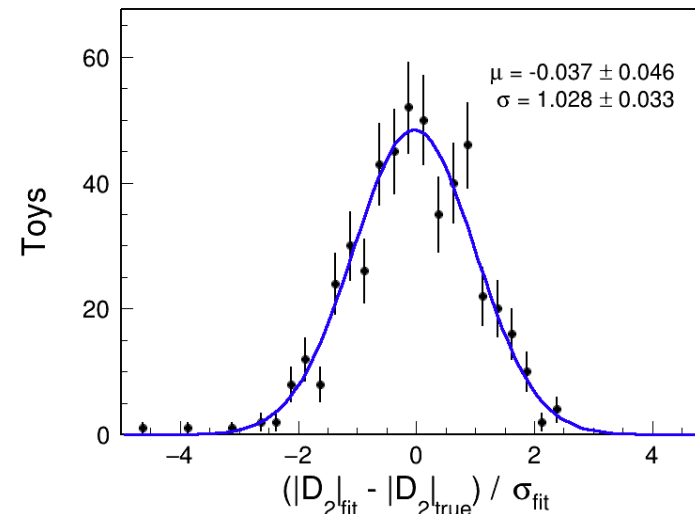
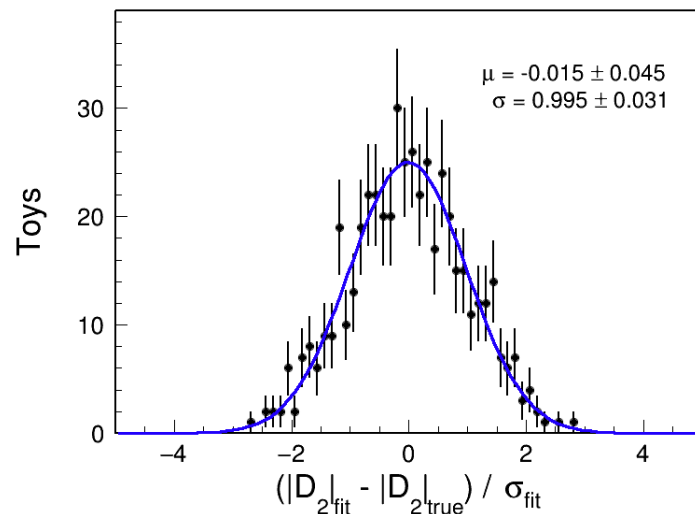
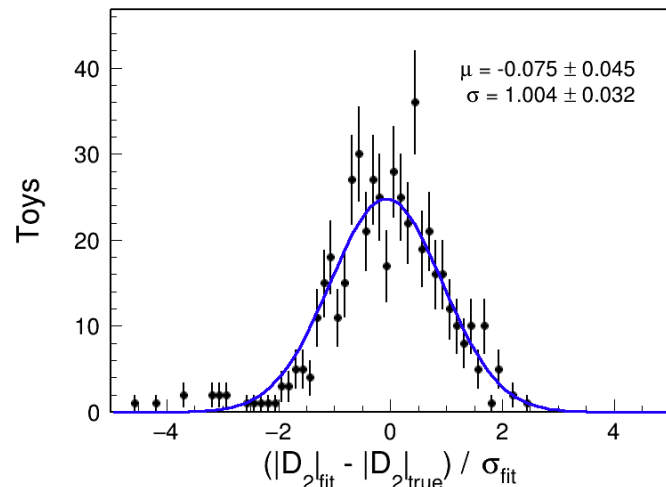
其中:

- $J = 2$  (母粒子  $X$  自旋),  $s_1 = 1$  ( $J/\psi$  自旋),  $s_2 = 1$  ( $\omega$  自旋)
- $\lambda = \lambda_1 - \lambda_2$  (螺旋度差)
- $\langle j_1, m_1; j_2, m_2 | J, M \rangle$  是标准的 Clebsch-Gordan (CG) 系数。

# 0+下检验

不同toyMC数据量样本: 200 (~B2data)  
500 (~B1+B2) 1000 (~2\*(B1+B2)data) 后续考虑固定  
振幅强度单独拟合相位

```
std::complex<double> S0(1.0, 0.0);  
std::complex<double> D2 = std::polar(0.6, acos(-1.0) / 6.);
```



200

500

1000

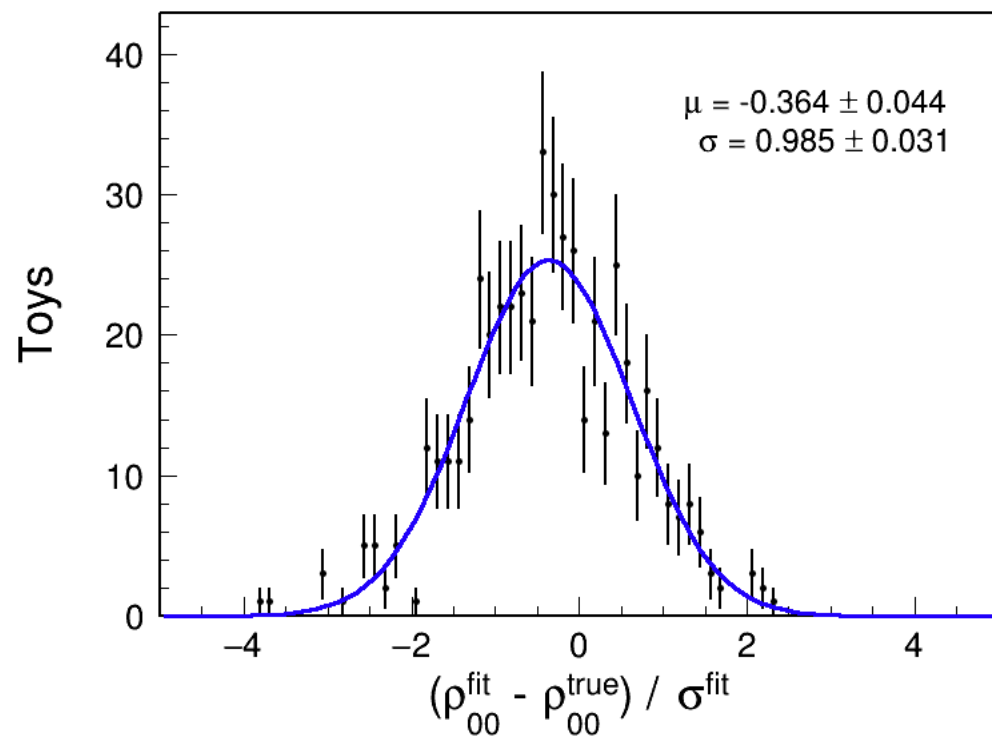
# 2+下检验

```
std::complex<double> S2(1.0, 0.0);  
std::complex<double> D0 = std::polar(0.1, acos(-1.0) / 6.);  
std::complex<double> D1 = std::polar(0.2, acos(-1.0) / 3.);  
std::complex<double> D2 = std::polar(0.3, acos(-1.0) / 2.);  
std::complex<double> G2 = std::polar(0.05, acos(-1.0) / 3. * 2.);  
double rho00 = 0.5;
```

$$\mathcal{A}_{\Lambda, \Delta\lambda_e} = \sum_{\lambda_1, \lambda_2} D_{\Lambda, \lambda_1 - \lambda_2}^{2*}(\phi_X, \theta_X, 0) \cdot H_{\lambda_1, \lambda_2} \cdot D_{\lambda_1, \Delta\lambda_e}^{1*}(\phi_{J/\psi}, \theta_{J/\psi}, 0) \cdot D_{\lambda_2, 0}^{1*}(\phi_\omega, \theta_\omega, 0)$$

$$I(\Omega) = \sum_{\Delta\lambda_e = \pm 1} [\rho_{22} (|\mathcal{A}_{+2, \Delta\lambda_e}|^2 + |\mathcal{A}_{-2, \Delta\lambda_e}|^2) + \rho_{00} |\mathcal{A}_{0, \Delta\lambda_e}|^2]$$

500个toyMC样本 数据量: 1000 (~2\*(B1+B2)data)



Fix住其余参数, 单独拟合 $\rho_{00}$