An attempt to search for the Time-Reversal Violation in τ system

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☞ INTRODUCTION

- The CP-Violation has been verified only in $K^0\bar{K}^0$ system.
- Its deep understanding is still missing.
- Most astrophysics investigations show that additional sources of CP violation, beyond the CKM, are necessary to account for the observed baryon-to-photon ratio of the universe.
- Leptonic CP violation would observe the interactions that can not be described in the frame work on the MSM since it arises only at the multiloop level (and is far below any measurable level). (by Chinese physicists)

☞ EXPERIMENT PRINCIPLE

- ❑ Consider the sequential transitions(Figure 1).
- ❑ Introduce the T-violation amplitude:

$$A = \langle\, \hat{p}_e \bullet (\hat{p}_1 \times \hat{p}_2)\rangle$$

if no T-violation, A is 0; if A is not 0, there is T-violation.
(by T.D. Lee)

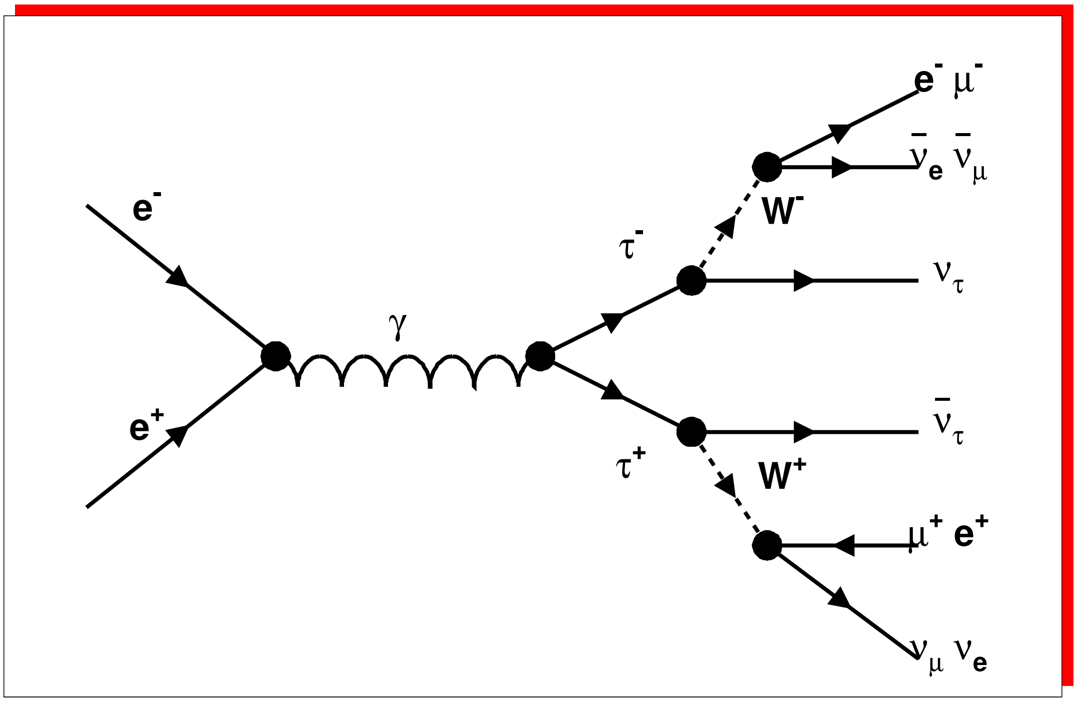

Figure 1

☞ EVENT SELECTION

- ❑ Cut criteria (similar to which is used in M_τ measurement);
  - ✧ exactly two oppositely charged tracks;
  - ✧ no isolated photons;
    $E_\gamma > 60$ MeV, angl(chrg,γ) > 12;
  - ✧ primary vertex request:
    radius < 1.5 cm; $|z| < 15$ cm;
  - ✧ acolinearity and acoplanarity angle requests;
  - ✧ one track is well identified as a muon and the other is well identified as an electron
- ❑ 432 $e\mu$ events have been selected from BES 1993 and 1994 data.
- ❑ The background rate is estimated to be 0.86%

☞ DATA ANALYSIS

- The amplitude for 432 eμ events is(Figure 2):

$$A = -0.027 \pm 0.031 \pm 0.006$$

the first error is statistic, the second is systematic.

better than 94 result(14 events):

$$A = 0.039 \pm 0.157 \pm 0.030$$

- The system error comes from:
  - the resolution of momentum of final particles(Figure 3), 0.0015;
  - the uncertainty of p_x and p_y of initial electron and positron(Figure 4), 0.0010,0.0005;
  - the spread of beam energy, 0.0021;
  - the background in the sample, 0.0050.

☞ DISCUSSION

- Not seen the T-violation in τ system yet;
- More samples needed to reduce statistic error;
- Better detector and accelerator needed to reduce the systematic error.
- BES BTCF

BES	BTCF
0.15%(σ_p/p=1.7%)	0.05%(σ_p/p=0.4%-0.1%)
0.1%($x_{cluster}$=1mm)	0.01%($x_{cluster}$=0.1mm)
0.01%($x_{cluster}$=0.4mm)	0.005%($x_{cluster}$=0.01mm)
0.21%(σE_{beam}=2MeV)	0.15%(σE_{beam}=1MeV)
	0.015%(σE_{beam}=0.1MeV)
0.5%(R_b=0.86%)	0.05%(R_b=0.086%)

- If the CP-violation exists in τ system, and the amplitude is as large as 0.1%, which is expected by Chinese theorist, we will observe it at BTCF.

Error propagation

For each charge track, we have a vector to describe it ($\vec{X}= (\phi, \frac{1}{p_{xy}}, \cot\theta)$). The errors of them have been given by reconstruction.

The relation between momentum and $\vec{X}$ is:

$$p_x = cos(\phi)P_{xy} = \frac{cos(X_1)}{X_2} \tag{1}$$

$$p_y = sin(\phi)P_{xy} = \frac{sin(X_1)}{X_2} \tag{2}$$

$$p_z = cot(\theta)P_{xy} = \frac{X_3}{X_2} \tag{3}$$

And the errors of momentum are taken from the propagation:

$$\sigma(P)^2 = D_P \sigma(X)^2 D_P^T \tag{4}$$

where, D_P is propagation matrix.

$$D_P = \frac{\partial(px, py, pz)}{\partial(X_1, X_2, X_3)} = \begin{pmatrix} \frac{\partial p_x}{\partial X_1} & \frac{\partial p_x}{\partial X_2} & \frac{\partial p_x}{\partial X_3} \\ \frac{\partial p_y}{\partial X_1} & \frac{\partial p_y}{\partial X_2} & \frac{\partial p_y}{\partial X_3} \\ \frac{\partial p_z}{\partial X_1} & \frac{\partial p_z}{\partial X_2} & \frac{\partial p_z}{\partial X_3} \end{pmatrix} \quad (5)$$

We can get the T-violation amplitude for each event:

$$\mathcal{A}_i = \hat{p}_e \cdot (\hat{p}_1 \times \hat{p}_2) \quad (6)$$

$$\sigma^2 \mathcal{A}_i = T\sigma^2(P)T^T \quad (7)$$

where, T is anothe propagation matrix.

$$T = \frac{\partial \mathcal{A}}{\partial(px, py, pz)} \quad (8)$$

FIGURES

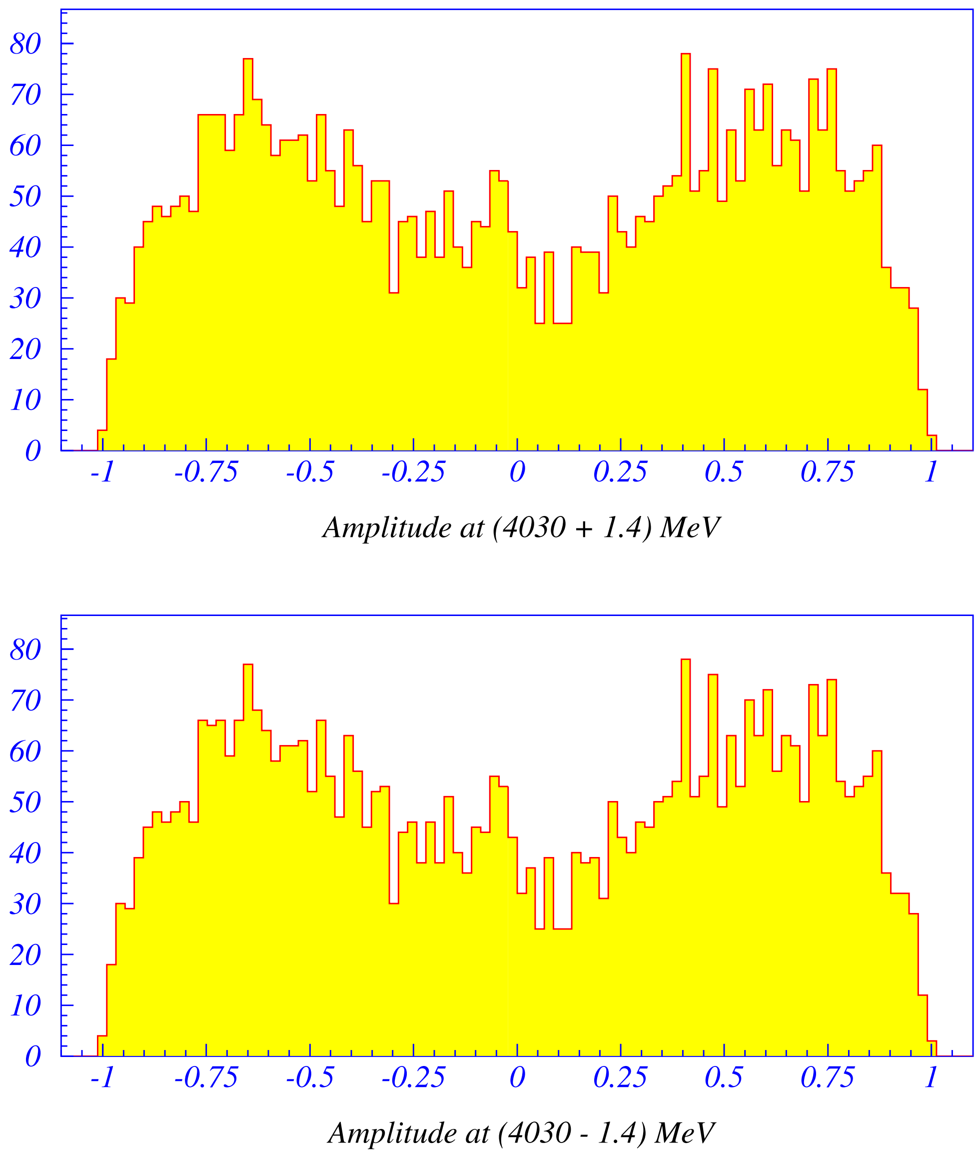

FIG. 1. systematic error of $\mathcal{A}$ from uncertainty of Energy of beam

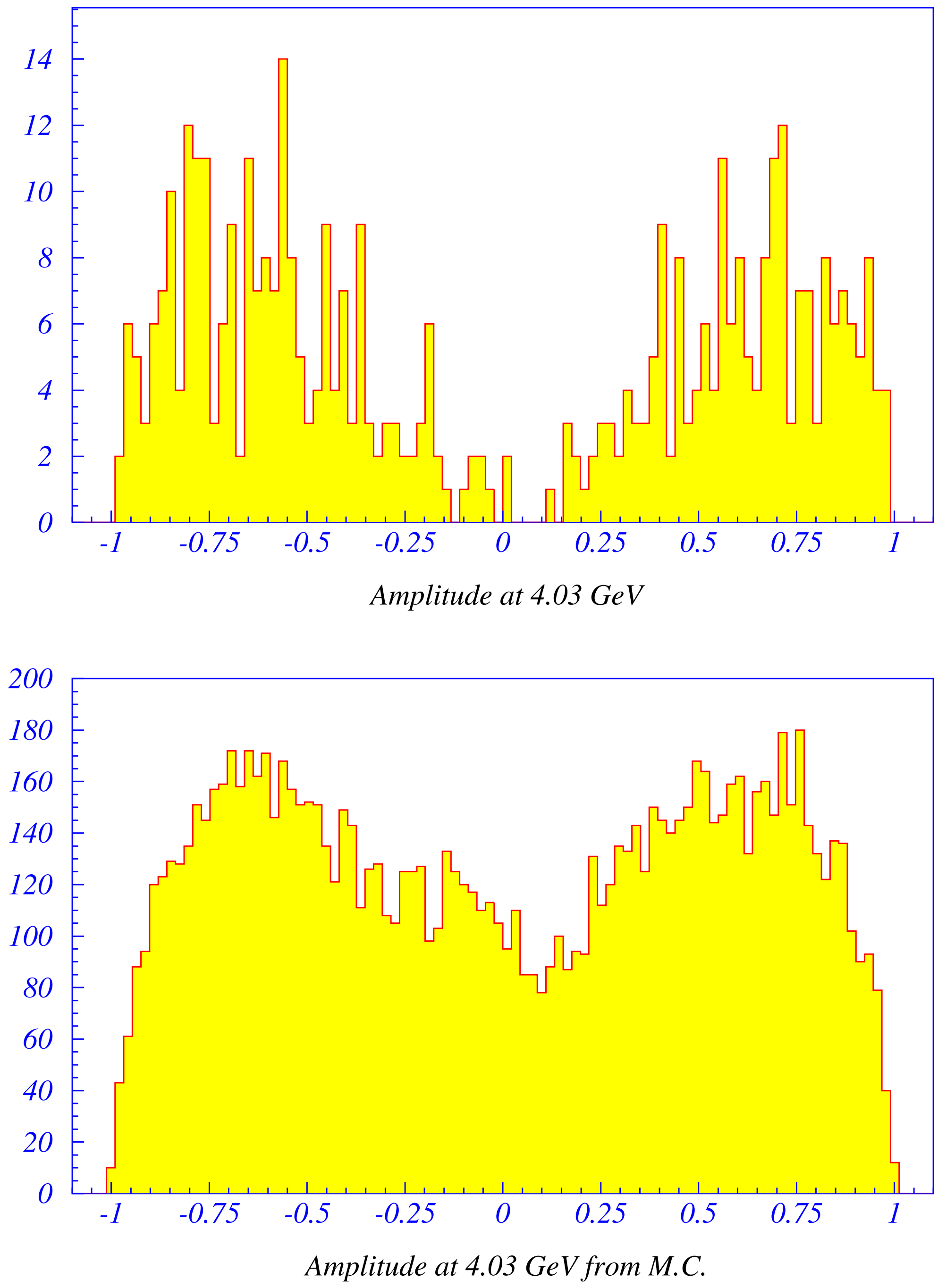

FIG. 2. $\mathcal{A}$ distribution from 432 events and M.C.

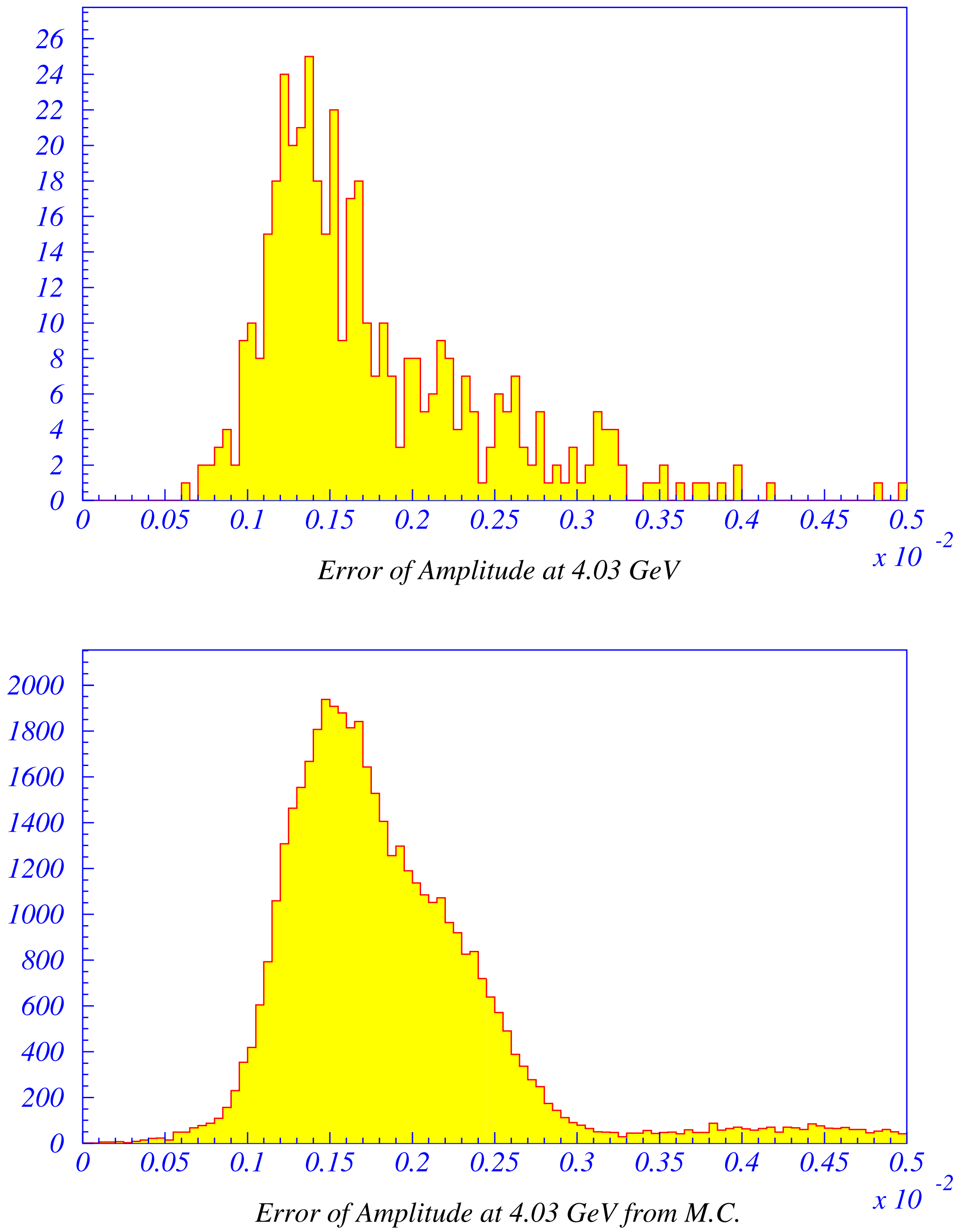

FIG. 3. systematic error of $\mathcal{A}$ from Momentum resolution

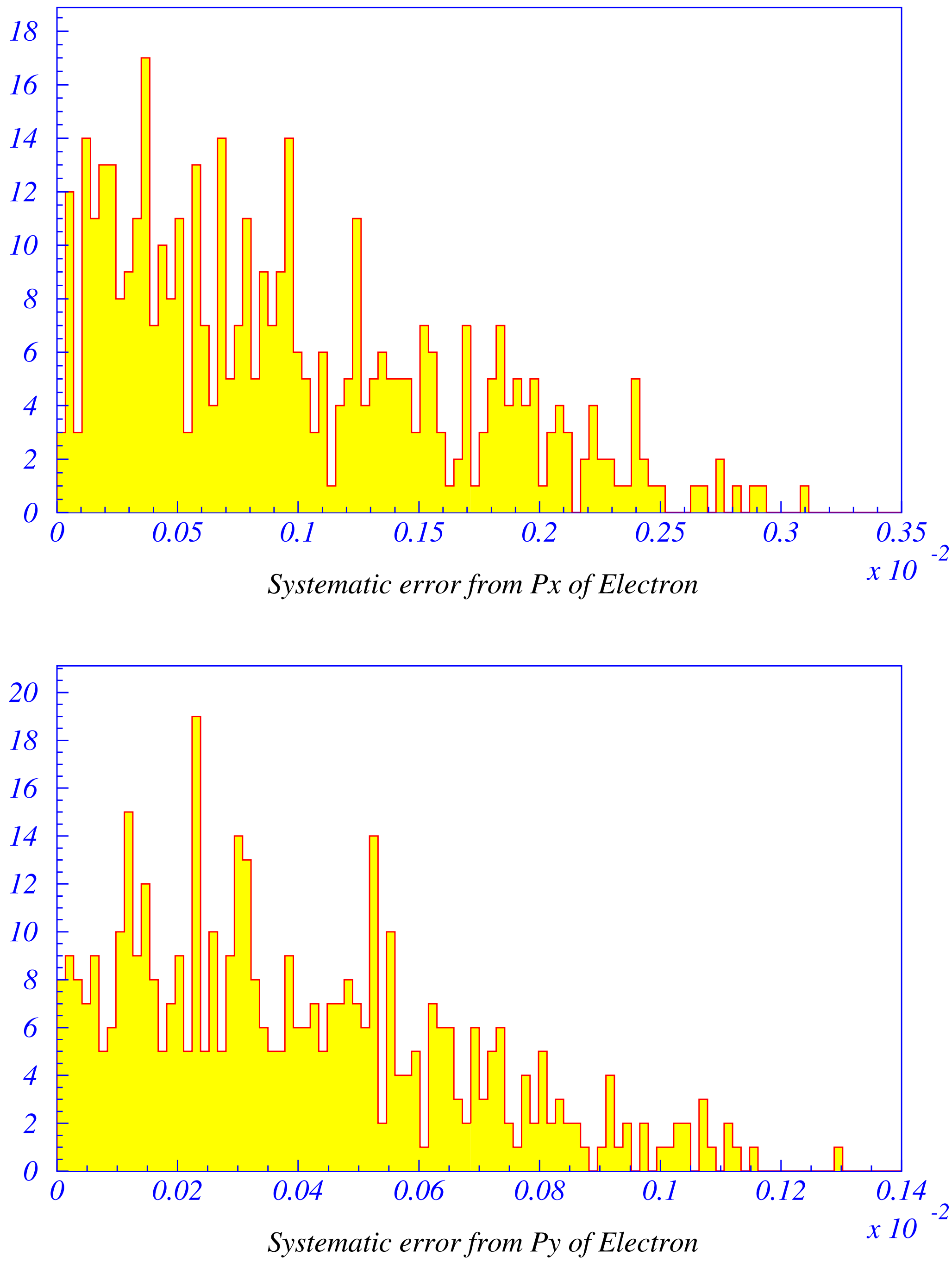

FIG. 4. systematic error of $\mathcal{A}$ from uncertainty of p_x of electron and positron of beam