A Test of Violation of Lepton Number in τ decay: search for $\tau \rightarrow e\gamma$ and $\mu\gamma$

(Reported by YU Guowei)
YU Yunhua YU Guowei
HangZhou Univisity
TONG Guoliang WU Yigen FENG Sheng
IHEP

June 12, 1997

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1 Introduction

The search for lepton number violation in τ decay has long been an area of interset. We present here a search for $\tau \rightarrow e\gamma$ and $\mu\gamma$ which donot contain ν_τ.

There were a lot of other group who searched for decay modes of the τ lepton which do not contain ν_τ. Their conclusion were:

(1). $\tau \rightarrow e\gamma$
E_{cm} = 10 GeV $B \leq 1.2 * 10^{-4}$ (ARG group)
E_{cm} = 10 Gev $B \leq 2.0 * 10^{-4}$ (CBAL group)
E_{cm} = 3.8-6.8 GeV $B \leq 6.4 * 10^{-4}$ (MARKII group)
(2). $\tau \rightarrow \mu\gamma$
E_{cm} = 10.6 GeV $B \leq 0.42 * 10^{-5}$ (CLEO group)
E_{cm} = 10 GeV $B \leq 3.4 * 10^{-5}$ (ARG group)
E_{cm} = 3.8-6.8 GeV $B \leq 55 * 10^{-5}$ (MARKII group)

2 Particle Identification

We analyse MC samples including e,π/μ,k,p,and identify them according to selecting functions whose coefficients are fitted through analying samples.

Then we can decrease mixture of e and π/μ,especially, decrease mixture of $\pi/\mu \rightarrow$ e in lower momentum with the way.

At first,we require:

$$\begin{aligned} 0 \le \beta \le 2 \\ -10 \le de/dx \le 5 \\ 0 \le E/P \le 2 \end{aligned}$$

1.To identify k from e and π/μ
In momentum range: 0.3-0.45 GeV,we select a function :

$$\begin{aligned} f_1 = \ & de/dx - ((8.0/p)\beta - 15.0) \\ & 0 \le f_1 \rightarrow kaon \end{aligned}$$

In momentum range: 0.45-1.5 GeV,we select a function :

$$\begin{aligned} f_2 = \ & E/P - ((-3.39/p)\beta + 3.05/p - 2.57) \\ & f_2 \le 0 \rightarrow k \end{aligned}$$

2. To identify p from e and π/μ
In momentum range: 0.5-0.85 GeV,we select a function :

$$\begin{aligned} f_3 = \ & de/dx - ((12.0/p)\beta - 10.0) \\ & 0 \le f_3 \rightarrow p \end{aligned}$$

3. To identify e and and π/μ In momentum range: 0.1-0.3 GeV,we select two functions :

$$\begin{aligned} f_1 = \ & de/dx - ((-2793.53p^2 + 1595.37p - 232.316)\beta & (1) \\ & +(2351.09p^2 - 1367.38p + 201.958)) & (2) \\ f_2 = \ & de/dx - ((-2880.08p^2 + 1675.85p - 247.927)\beta & (3) \\ & +(2218.16p^2 - 1329.11p + 200.236)) & (4) \\ & 0 \le f_1, f_2 \rightarrow e & (5) \\ & f_1, f_2 \le 0 \rightarrow \pi/\mu & (6) \end{aligned}$$

In momentum range: 0.3-1.5 GeV,we select two functions:

$$\begin{aligned} f_1 = \ & de/dx - ((-0.928p^2 - 7.49p + 248.835)E/P & (7) \\ & +(0.2524p^2 + 5.735p - 2.672)) & (8) \\ f_2 = \ & de/dx - ((-5.005p^2 - 11.178p + 2.992)E/P & (9) \\ & +(-3.313p^2 + 12.362p - 5.784)) & (10) \\ & 0 \le f_1, f_2 \rightarrow e & (11) \\ & f_1, f_2 \le 0 \rightarrow \pi/\mu & (12) \end{aligned}$$

With these cuts,we can obtain:
(1) . The efficiency of selecting e is:

77.62% (0.1-0.3 GeV) (see figure(1))
89.65% (0.3-1.5 GeV) (see figure(2))
(2) . The efficiency of selecting π/μ is:
81.28% (0.1-0.3 GeV) (see figure(3))
89.14% (0.3-1.5 GeV) (see figure(4))
(3). The background ratio($\pi/\mu \rightarrow$ e) is:
1.11% (0.1-0.3 GeV) (see figure(5))
0.073% (0.3-1.5 GeV) (see figure(6))
(4). The background ratio(e $\rightarrow \pi/\mu$) is:
2.99% (0.1-0.3 GeV) (see figure(7))
0.338% (0.3-1.5 GeV) (see figure(8))

3 Event Selection Cuts

1.$\tau\tau$ event level cuts
a.nchrg=2
b.$1 \leq nneu \leq 6$
c.ΣQ=0
d.Mfit=2 or -19
e.vertex cuts:
$|x| \leq 0.015m$
$|y| \leq 0.015m$
$|z| \leq 0.15m$
f. $|cos\theta| \leq 0.8(\theta is the polar angle of charge track)$
g. $|Tof(1) - Tof(2)| \leq 4ns$
h. $5^0 \leq sacop$
$5^0 \leq sacol \leq 175^0$
2.$\tau \rightarrow$ l+γ(l:μ or e) event level cuts
The definition for isolated photon is:
(1).The angle(θ) between the photon and each charge track: $15^0 \leq \theta$
(2).The energy (Er) deposited in BSC: $50MeV \leq Er$
(3).$\alpha = arcos^{-1}\{\vec{R_a}\vec{R_c}/(|R_a||R_c|)\} \leq 18^0$
R_a: the momentum direction of photon
R_c: the development direction of photon in BSC
a.We required one charge track was identified as e and another charge track was identified as $\pi/\mu(\tau \rightarrow e\gamma)$;
or a charge track was identified as μ and another charge track was identified μ or e($\tau \rightarrow \mu\gamma$).
b. $0.55GeV \leq p_1 \leq 1.5GeV$
$0.1GeV \leq p_2 \leq 1.5GeV$
c. $0.1 \leq ptes$
d. $P_{miss} = |\Sigma\vec{p_q} + \Sigma\vec{p_\gamma}|$
$E_{miss} = E_cm - (\Sigma E_q + \Sigma E_\gamma|$
ΣE_q: total energy of charge track

ΣE_γ: total energy of neutral track

$\Sigma \vec{p_q}$: total momentum of charge track

$\Sigma \vec{p_\gamma}$: total momentum of neutral track

According to MC data,we require:

$0.6 \leq E_{miss}/P_{miss}(\tau \to e\gamma)$

(To reject $\tau^+\tau^-$ mixture background) (see figure(10))

$0.52 \leq E_{miss}/P_{miss}(\tau \to \mu\gamma)$

(To reject dimu background) (see figure(12))

e.The angle(α) between $\Sigma \vec{p_\gamma}$

and $\Sigma \vec{p_q}$ must require:

$-0.95 \leq cos\alpha \leq -0.05$

(To reject bhabha (or dimu) and $\tau^+\tau^-$ mixture background) (see figure(13,14,15,16))

f.We required that there were at least a isolated photon , the energy of photon required:

$0.52 \leq E_\gamma$

(To reject $\tau\tau$ mixture background) (see figure(9,11))

$|E_\gamma - E_{used}| \leq 0.22\sqrt{E_{used}}$

Here $E_{used} = E_{beam} - E_l$,$E_l$ is the energe of lepton: and the photon must not be reconstructed with another photon to π^0:

$0.25GeV \leq M_2\gamma$ or $M_2\gamma \leq 0.05GeV$

g.To fit mass $M_l\gamma$,and $M_l\gamma$ require:

1.$M_{l\gamma} = [M_{l^2} + 2E_\gamma(E_l - P_l cos\theta)]^{1/2}$ (see figure(17,18,19,20))

(1).Here $E_l and P_l$ are the energy and momentum of lepton ; E_γ is the energy of the photon; θ is the angle between the lepton and photon.

But in practice E_γ is nearly replaced by E_{used}

2. $|M_{l\gamma} - M_\tau| \leq 24MeV$

M_τ is the mass of τ lepton.

With these cuts, we can obtain the acceptance with ($\tau \to$ l+γ) MC data (10000 events).

The acceptance is 2.46%($\tau \to e\gamma$) or 1.81%($\tau \to \mu\gamma$).

4 Background Estimation and Data Analysis

1. Background estimation using MC data.

We have analysed the different background MC data that were equal to the integral luminosity 23 pb^{-1} experimental data, which include hadron, bhabha,$\tau\tau$ events , two γ process,dimu events.

There is no enevt selected as the radiative decay of τ.

2.Analysis Experimental Data

We have analysed 23 pb^{-1} experimental data, and not found eγ and $\mu\gamma$ candidate.

5 Result and Discussion

1.$B \leq \lambda(N_{obs})/[2\Sigma\sigma(\mathrm{E})\mathrm{L}(\mathrm{E})\mathrm{A}(\mathrm{E})]$

Here $\lambda(N_{obs})$ is the average value for a possion distribution such that there is a 90% probability. N_{obs} is the number of events observed.σ(E) is the $e^+e^- \to \tau^+\tau^-$ cross section.

L(E) is the luminosity,A(E) is the acceptance,and E is the center-of-mass energy. through discussion above,we can obtain:

a.$\tau \rightarrow e\gamma$

$\lambda(N_{obs}) = 2.3, \sigma(E) = 3.5nb, L(E) = 23pb^{-1}, A(E) = 2.46\%$

then we cab obtain :

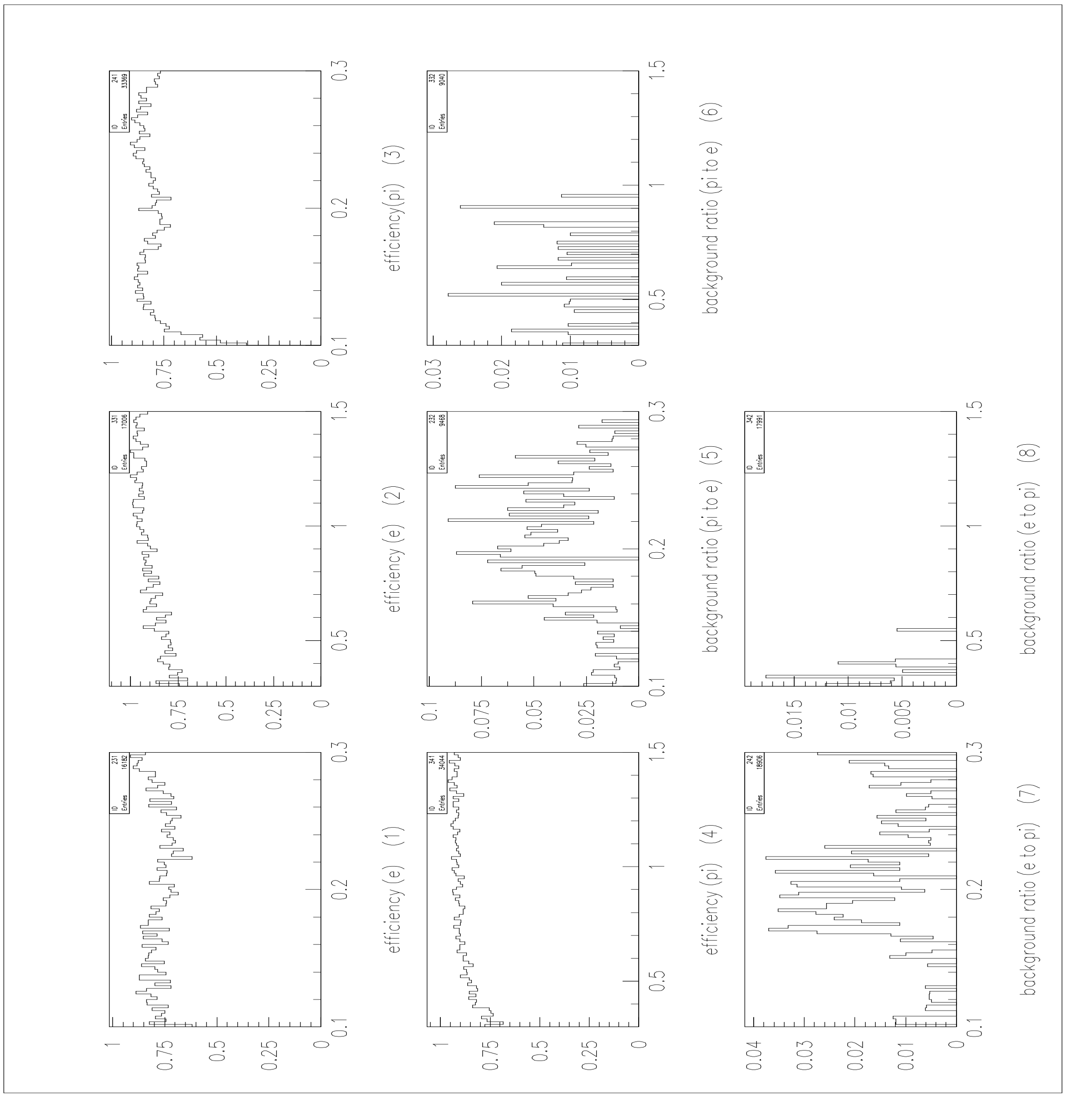
$B \leq 5.81 * 10^{-4}$

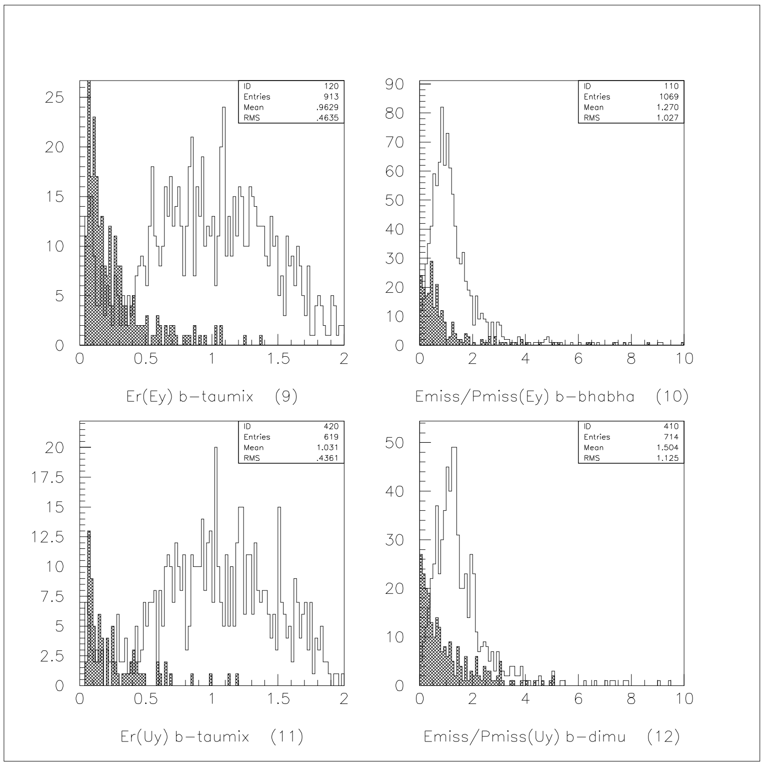
b.$\tau \rightarrow \mu\gamma$ $\lambda(N_{obs}) = 2.3, \sigma(E) = 3.5nb, L(E) = 23pb^{-1}, A(E) = 1.81\%$

then we cab obtain :

$B \leq 7.89 * 10^{-4}$

2.We have searched for $\tau \rightarrow e\pi^0$ and $\tau \rightarrow \mu\pi^0$ modes,and obtained preliminary result , but it needs further study.

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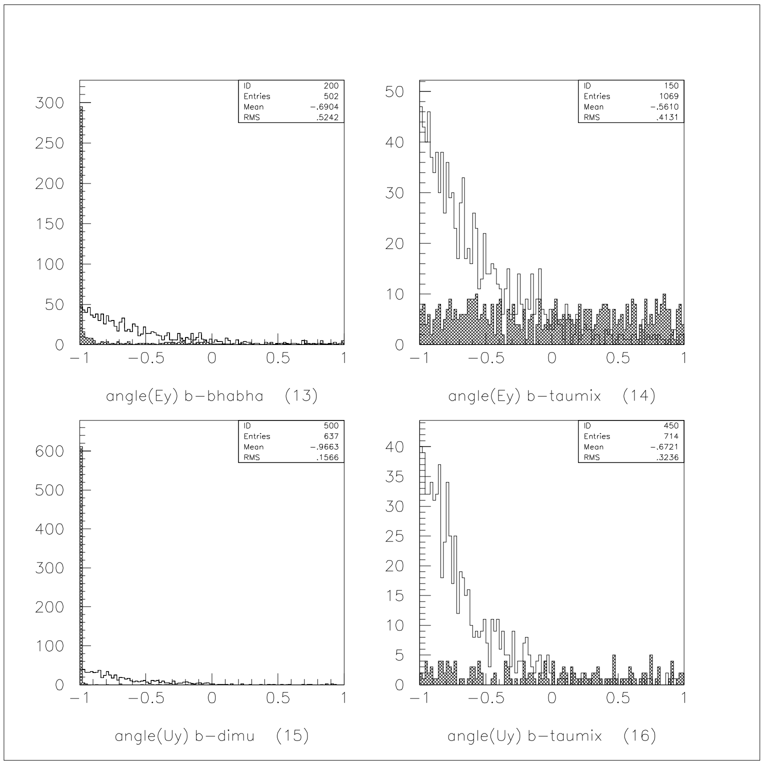
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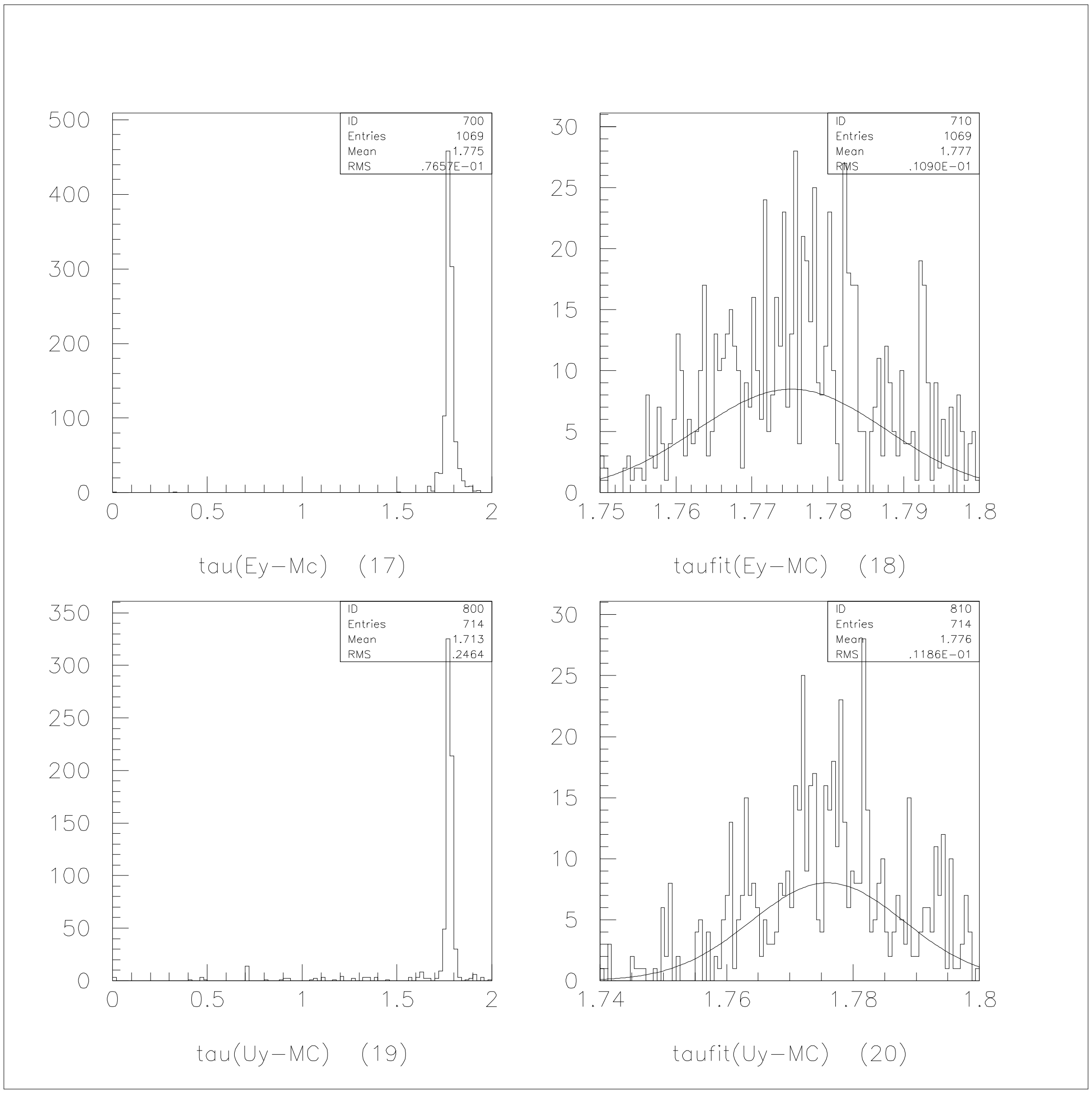
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taufit(Uy−MC) (20)