Testing Lepton Flavor Conservation Law(LFCL) in J/ψ Decay

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• Introduction

– Motivation

In the Standard Model,total and individual lepton numbers are conserved.But in many extensions of the SM,such as SUSY, Left-Right Symmetric Models,lepton numbers are violated.

Super-Kamiokande[1] indicates $m_\nu \neq 0$,then LF symmetries are broken.So it's necessary to test it in experiment.

– Theoretical Consideration

1. We have had very large samples(7.8x10^6) of J/ψ in the world(BESI),and we will accumulate about 5x10^7 J/ψ Data in two years, so we trust we can obtain more accurate conclusion about LFCL in the J/ψ Decay:
   $J/\psi \to e\mu$
2. Experimental Measurement on Br($J/\psi \to e\mu$) is interesting(No data exists in Particle Data Book).
3. Theoretical Consideration[2]

According to the theory by Prof.Zhang,we can know the upper limit of branch ratio ($J/\psi \to e\mu$) is :

Br $< 10^{-6}$ (Depend on momtenum linearly) or

Br $< 10^{-9}$ (Depend on momtenum quadratically)

• Events Selection of $J/\psi \to e\mu$

In $J/\psi \to e\mu$ process,two opposite charged particles should be detected by MDC and the total charges of these tracks should be eaqul to zero.For one track fit the M_{fit}=2 or -19 is required.The total number of neutral tracks must be less than four.

$J/\psi \to e\mu$ is back-to-back process,the angle θ_{acol} between two charged tracks must be more than 175^0

The mass of e and μ are little contrasting to their momentum, so the momentum of charged tracks are required :

$1.45 < p < 1.65GeV$ (see Fig.1)

We use the total energy(E) observed in SC and momentum(P) from MDC to identify e and μ:

First we need identify e from e,μ and π:

E/p > 0.7 (e), E/p < 0.3 (μ or π)

Because MC can't simulate the information fof BSC well,we select some samples of e and μ from experimental data.The following is information of E/p from samples of e and μ (see Fig.2):

Second,we need to identify μ using information of μ counter with general criteria:

P_{xy}	μ_{hit}
$P_{xy} < 0.75$GeV	$\mu_{hit} >0$
$0.75 < P_{xy} < 0.95$GeV	$\mu_{hit} \geq 2$
$P_{xy} > 0.95$GeV	$\mu_{hit}=3$

Using the information of P_{xy},we can identify μ from π.

There is no isolated photon in $J/\psi \to e\mu$,so events with isolated photon must be rejected.The following are the criteria to select isolated photons:

$E_{sc} \geq 50MeV$, $\theta_{\gamma c} > 15^0$,

$\alpha < 18^0$ (α is the angle between the hiting direction and devoleping direction at BSC)

At last,we require invariant mass of e and μ be:

$2.95 < M_{e\mu} < 3.25$ GeV (see Fig.3)

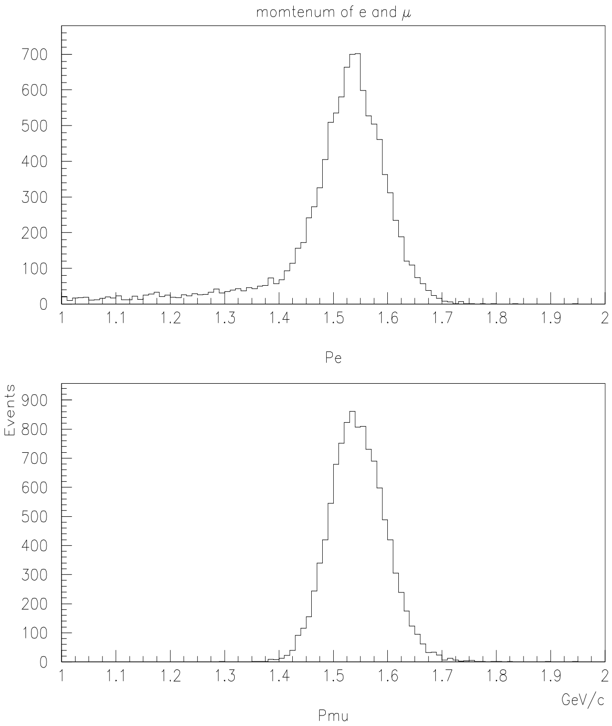

Figure 1:

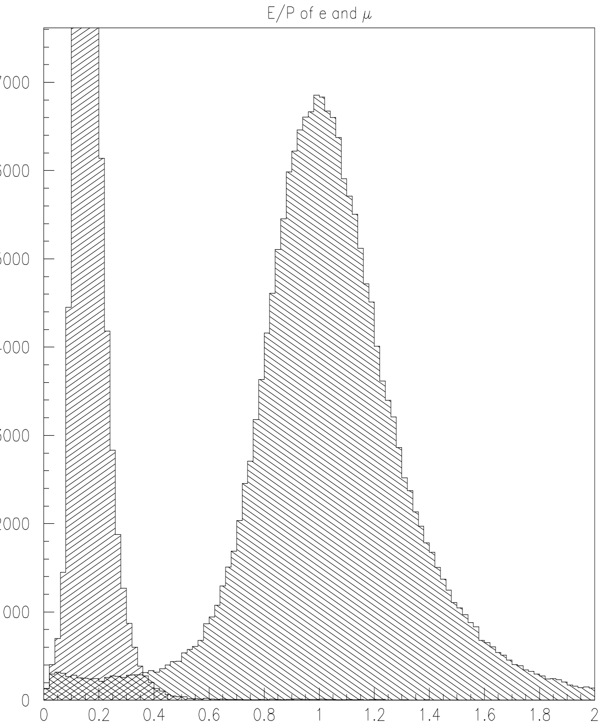

Figure 2:

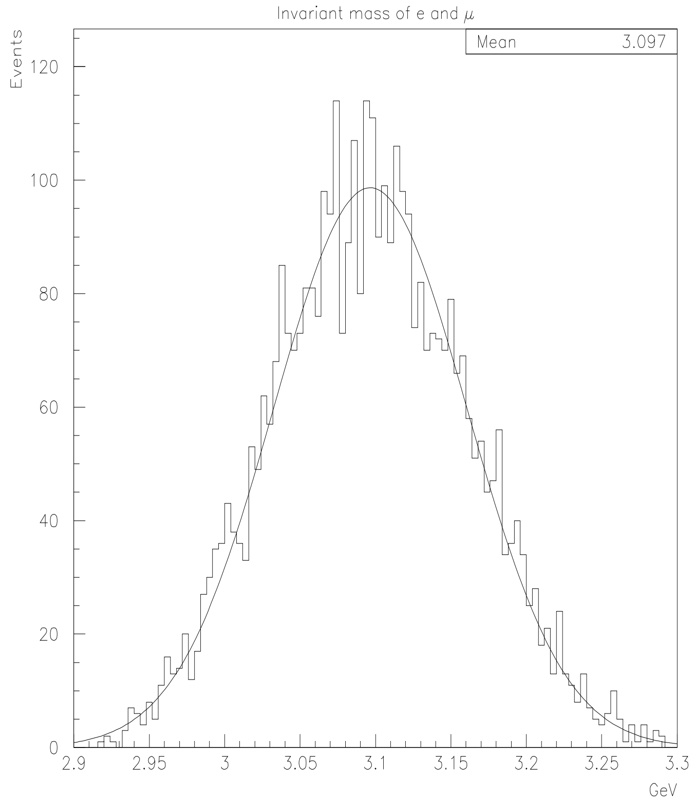

Figure 3:

The following are the list of main cuts and the number of test data in $J/\psi \to e\mu$:

Cuts	Test data
$N_{chrg} = 2$	1503142
vertical cuts	1270459
M_{fit}=2,-19	1270459
ΣQ_i=0	1270459
ISUB > 0	803634
$1.65 > P > 1.45 GeV/c$	381979
E/P cut	11014
$N_{mulayer>0}$=1	775
μ identification	5
N_{iso}=0	4
$3.25 > M_{e\mu} > 2.95$GeV	4

- **Results**
  - By Generating 20000 MC events(the generator is given by Prof.Zhang Dahua), the selection efficiency has been obtained:ϵ=21.6%.
  - All BESI J/ψ events have been analysed,four candidates are found. The irun/irec of events are :1582/24773,3589/21502,3595/8579,3621/24496 (see FIG.4,5,6,7).
  - Because MC can't simulate the information of BSC and μ counter well,we used samples of $J/\psi \to ee$ and $J/\psi \to \mu\mu$ to correct efficiency and analyse the backgound events.

    From above samples,we begin to calculate the total background rates of $J/\psi \to ee$ and $J/\psi \to \mu\mu$.
  - Calculate the background rate:

    First we calculate the rates through detectors except μ counter and BSC by using MC;

    Second,we calculate the rates through μ counter and BSC by using samples;

    At last,we get the total background rate by timing two rate above.

    According to discussing above ,we select 211 events from 397634 $J/\psi \to ee$ sample and get the rate is 2% from MC,then we can know the background rate($J/\psi \to ee$) is about 10^{-5};using same way,we select 10464 events from 122141 $J/\psi \to \mu\mu$ and get the rate is about 2x10^{-4} from MC,so the background rate($J/\psi \to \mu\mu$) is about 2x10^{-5}.

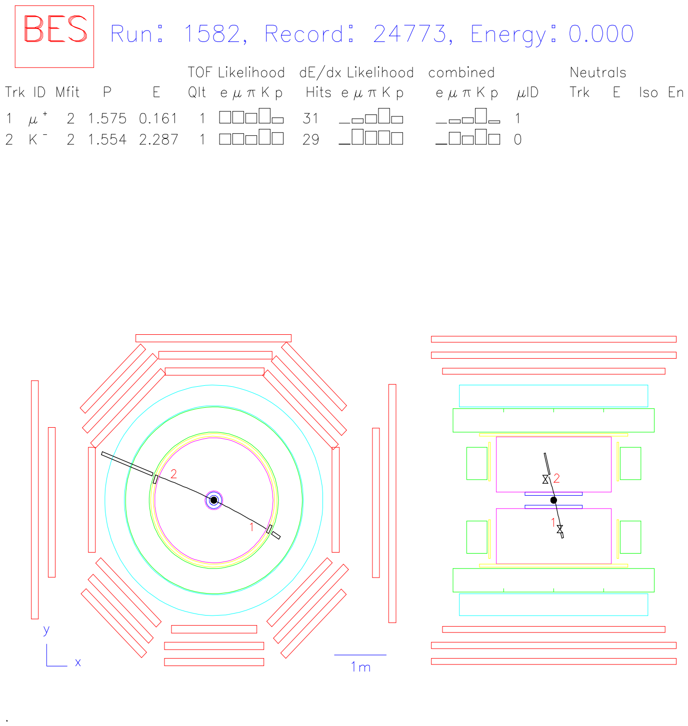

Figure 4:

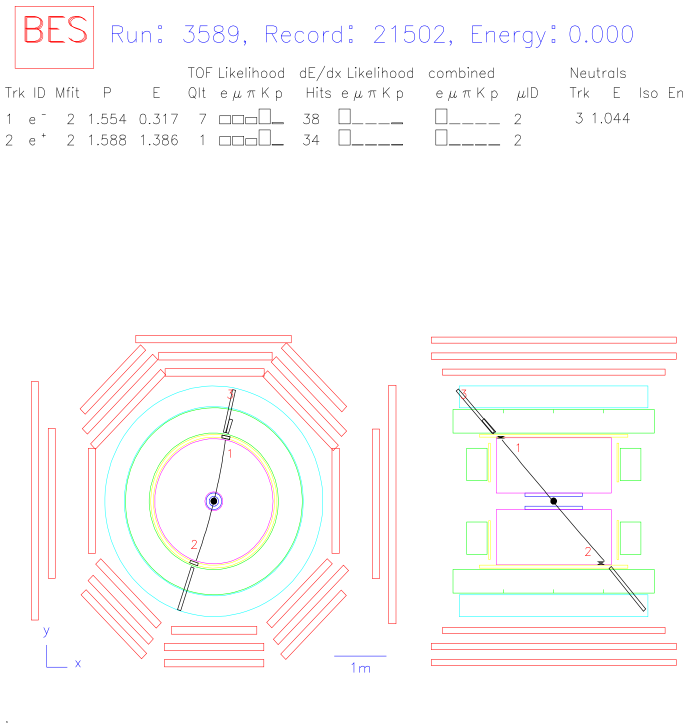

Figure 5:

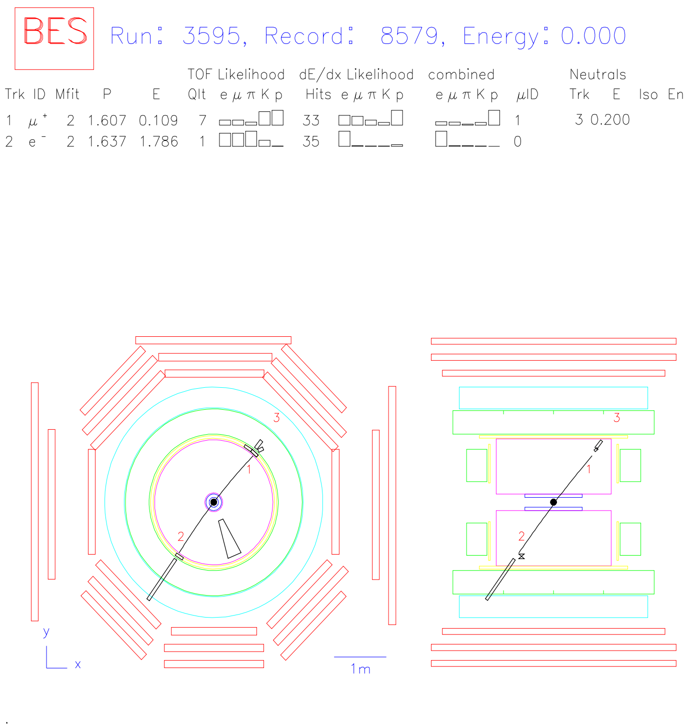

Figure 6:

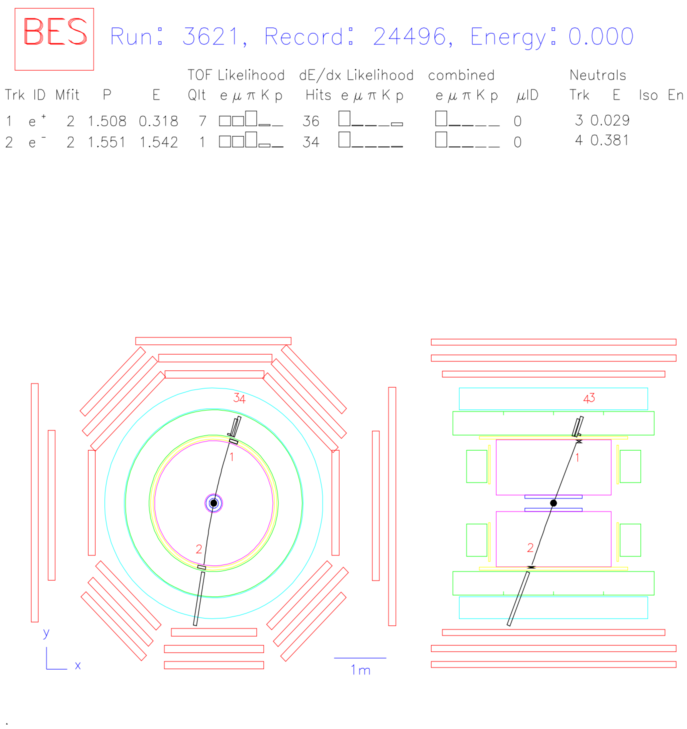

Figure 7:

The following are the information of four events

RUN:1582 IREC:24773

	μ	e
P	1.57GeV	1.55GeV
E_{sc}	0.16GeV	2.29GeV
E/P	0.16	1.47
β	0.94	0.91
θ	0.10	-0.11
phmp	1010	1120
μ_{hit}	3	0
$M_{e\mu}$	3.104GeV	

RUN:3589 IREC:21502

	μ	e
P	1.55GeV	1.59GeV
E_{sc}	0.32GeV	1.39GeV
E/P	0.20	0.87
β	0.92	0.92
θ	-0.65	0.65
phmp	1359	1437
μ_{hit}	3	0
$M_{e\mu}$	3.113GeV	

RUN:3595 IREC:8579

	μ	e
P	1.61GeV	1.64GeV
E_{sc}	0.11GeV	1.79GeV
E/P	0.068	1.09
β	0.87	1.04
θ	0.54	-0.52
phmp	1173	1300
μ_{hit}	3	0
$M_{e\mu}$	3.214GeV	

RUN:3621 IREC:24496

	μ	e
P	1.51GeV	1.55GeV
E_{sc}	0.32GeV	1.54GeV
E/P	0.21	0.99
β	1.18	1.11
θ	0.36	-0.34
phmp	1346	1533
μ_{hit}	3	0
$M_{e\mu}$	3.029GeV	

From discussing above,we can get the upper limit of Br($J/\psi \to e\mu$):

$Br < \lambda(N_{obs})/[2N_T\epsilon]$

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. N_T is the total number of J/ψ. ϵ is the efficiency.At last,we can obtain:

$$Br < 2.31\text{x}10^{-6}$$

We also started to search:

$J/\psi \to e\tau$

$J/\psi \to \mu\tau$

We analysed all new J/ψ data(BESII:RUN13500-17018) preliminarily and found 6 candidates.

After BES accumulates $5\text{x}10^7$ J/ψ events ,the upper limit will be much improved.

Reference

[1] Y. Fukuda et al. (Super-Kamiokande Collabration), Phys. Rev. Lett., 1998, 81:1562

[2] S. Nussinov, R. D. Peccei and X. M. Zhang, hep-ph/0004153