Gsim study of
Test of T/CP invariance
in $e^+e^- \to \tau^+\tau^-$ reaction

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- Introduction

Reaction

$e^+e^- \to \tau^+\tau^- \to (e^+/\mu^+)\ \nu\ \nu\ (e^-/\mu^-)\ \nu\ \nu$

measure directions of 2 leptons(e/μ)

triple momentum correlation A

$A = p_1 \cdot (p_2 \times p_3)$

p_1: unit vector of e^- beam momentum

p_2: unit vector of e^+/μ^+ momentum

p_3: unit vector of e^-/μ^- momentum

$R = 1+4\delta$

$$= \frac{N(\mu^+e^- ; >)}{N(\mu^+e^- ; <)} \frac{N(e^+\mu^- ; >)}{N(e^+\mu^- ; <)}$$

δ denotes T/CP violation portion.

- Event pre-selection

- selection criteria

2 <= # of good charged track <= 8

Σ Pcm < 10 GeV/c →bhabha, μμ

Σ E(ECL good cluster) < 10 GeV →bhabha

Pt > 0.5 GeV/c for at least 1 track →2 photon, beam BG

Event vertex |r|<0.5cm, |z|<3cm →beam BG

for 2 track events

Σ Pcm < 9 GeV/c →bhabha

Σ E(ECL) < 9 GeV →bhabha

$5 < \theta_{Pmiss} < 175$ degree →2 photon

- result

	accepted rate	generated cross section	observed cross section	
τ pair	72.7%	0.91nb	0.66nb	(6.3%)
μ pair	5.45	0.94	0.05	(0.5%)
bhabha	0.45	1249	5.6	(53.4%)
eeee	1.68	40.88	0.68	(6.4%)
eeμμ	2.26	18.80	0.42	(4.0%)
bb	57.3	1.05	0.60	(5.7%)
conti.	73.5	3.39	2.49	(23.7%)
			10.52nb	(100%)

- Event selection for $\tau\,\tau \rightarrow e\,\mu\,4\nu$

- selection criteria

cut-1 (multiplicity)

# of good charged track = 2

Net charge = 0

# of good gamma = 0

cut-2 (momentum)

Σ Pcm < 9 GeV/c

Pcm < 5 GeV/c for all track

$-0.950 < \cos(\theta_{Pmiss}) < 0.985$ → 2 photon

cut-3 (PID)

$-0.60 < \cos(\theta_{Plab}) < 0.83$ ← barrel region

→ 2 photon rejection

muon :

P_{lab} > 1.2 GeV/c

μ ID flag >=2

electron :

P_{lab} > 0.5 GeV/c

electron probability > 0.90

(→ change to box cut (le_noeop,eoverp))

-result

mode	$\tau\,\tau$	$ee\mu\mu$	BB	conti.	$\mu\,\mu$	bhabha
Generated	1M	1M	500k	700k	500k	500k
	0.91nb	18.80nb	1.05nb	3.39nb	0.94nb	1249nb
Pre-selected	72.6%	23.4%	—	—	5.5%	0.5%
Passed cut-1	14.0%	19.2%	0	0.7%	2.2%	0.3%
cut-2	12.1%	8.3%	0	0.2%	0.7%	0.1%
observed cross-section (pb)						
$e^+\mu^-$	4.7pb	0.2	0	0	0	0
μ^+e^-	4.7	0.3	0	0	0	0
e^+e^-	5.9	0	0	0	0	20
$\mu^+\mu^-$	3.5	3.0	0	0	1.9	0

for $\tau\,\tau$

	accepted rates	mis-PID rate
$e^+\mu^-$	0.52%	4.2%
μ^+e^-	0.51%	3.8%
e^+e^-	0.64%	0.3%
$\mu^+\mu^-$	0.38%	7.6%

- result

for $\tau\,\tau$ 1M sample (~1fb^{-1})
$e^+\mu^-$ 5234 events
A>0 2663
A<0 2571
μ^+e^- 5113
A>0 2528
A<0 2583

Backgrounds
eeμμ ~5% $(\Delta N_{BG}/\Delta N_0)^2$~0.05
mis-PID ~4% $(\Delta N_{BG}/\Delta N_0)^2$~0.04

$$\Delta R = 2\ \frac{R}{\sqrt{N_0}}\ \sqrt{1+(\frac{\Delta N_{BG}}{\Delta N_0})^2}$$

→
$R = 1.012 \pm 0.042$

$\Delta\delta = 0.010$ at 1fb^{-1}

Data analysis (test)

- Data set
  - Luminosity runs ~10pb^{-1} (run380~450)
  - Pre-selected by trigger status
    → 2 track trigger is not applied.
  - trouble of skimmed data output
    → Many data are not skimmed completely.
- result

$e^+\mu^-$	21 events	(MC expect.	~50)
μ^+e^-	27 events	(	~50)
$R = 2.0 \pm 1.2$		(	$\pm$ 0.4)

Plan

- TSim for trigger pre-selection
  now checking tsim module
  put_parameters ?
- 2 photon background
  N(opposite charge) > N(same charge) by MC
  $N(e^+\mu^-)=8$ $N(e^+\mu^+)=2$
  $N(e^-\mu^+)=16$ $N(e^-\mu^-)=3$
  → selections or aafhb make some systematics ?

- PID study (muon ID of real data)
  by τ pair's 1-3 topology event