Searches for Lepton Flavour Violation

A) Report from the

7th International Workshop

on

Tau Lepton Physics

at

Santa Cruz

10-13 September 2002

TAU02

B) Preliminary Results of

Search for $e^+e^- \to \mu^\pm\tau^\mp$ in BaBar

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21st October 2002

TAU02 - Day 1

Opening Review by A. Pich (Valencia)

- Lepton Universality OK
  $\frac{\tau\to\mu}{\tau\to e} = 1.0003 \pm 0.0024$
- Branching Ratios measured to $\approx 3.5 \times 10^{-3}$ precision
- Hadronic Decays & QCD Tests probing the V-A Current
- Solar Neutrino Problem (SOLVED - Results from SNO ...
- Lepton Mixing & Flavor Violation

followed by Experimental Results

- Decay Branching Fractions - **CLEO** & **ALEPH**
- Lepton Flavor Violation Decay Searches - **CLEO**, **Belle** & **BaBar**

Theoretical Aspects of τ decays

- Expectations of Rare & Forbidden Decays (E.Ma - Riverside)
- Tau Spectral Functions & QCD (M. Davier - Orsay)
- Pion Form Factors from $\tau^{\pm} \rightarrow \pi^{\pm}\pi^{o}\nu_{\tau}$ and $\tau^{\pm} \rightarrow \pi^{\pm}\pi^{+}\pi^{-}\nu_{\tau}$
  compared with those from $e^{+}e^{-} \rightarrow$ multipions.

Use of τs in particle searches at LEP and in the future at LHC.

Neutrino Physics

- Recent results from: Super Kamiokande, K2K, SNO .....
- Status Reports on Super Kamiokande, Minos, CERN-GranSasso Mini Boone ....

TAU02 - Day 4

Half-day with

- MC Programs - TAUOLA, KORALB
- Panel Discussion of what to expect from the B-Factories
  Rather Dull !
- Summary Talks:
  - **Neutrinos - J.Gomes-Cadenas (Valencia)**
    - Super-KK $\chi^2 = 456.5$ for No-Oscillation - 17 d.o.f.
    - Threshold for $\nu_\tau \to \tau = 3.5GeV$ SuperKK should/do (?) see τs !!!
    - M_{ν_τ} measurement in $\tau^+ \to 3\pi^+ 2\pi^- \nu_\tau$ - End-point of $E_{5\pi}$ - in B-Factories
    - Long Baseline Experiments - K2K preliminary result
      $\Delta M^2 = 2.70 \pm 0.3 \times 10^{-3} eV^2$
  - **Taus - F. Gilman**

  Historical talk from discovery to present day.

- $\geq$ 2 Decades **S T U P I D I T Y**
- $\approx$ 1 Decade **E C C E N T R I C I T Y**
- Now **F A S H I O N A B L E**

ν Oscillations - fact !

Extension to SM (SUSY, L-R Symmetry ...) all predict LFV

Neutrinoless τ-decays favorable in comparison to μ-decays

$BR(\tau \rightarrow \mu\gamma) \simeq 10^5 \times Br(\mu \rightarrow e\gamma)$

PDG 90% CL $Br(\mu \rightarrow e\gamma) < 1.2 \times 10^{-11}$

$\Rightarrow BR(\tau \rightarrow \mu\gamma) \simeq 10^{-6}$ —- OBSERVABLE

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Tau02: $\tau \longrightarrow \mu\gamma$

Expected Background from

- $e^+e^- \rightarrow \tau^+\tau^-(\gamma)$ with
  $\tau^- \rightarrow \mu\nu\nu$ and
  $\tau^+ \rightarrow e^+\nu\nu,\ \pi^+\nu,\ \rho^+\nu,\ a_1^+\nu$
- $e^+e^- \rightarrow \mu^+\mu^-(\gamma)$

Event Selection:

- 2 Charged Tracks ($P_{Chg.} < 4.5\ GeV/c$)
- $\geq$ 1 Photon and
- Missing Energy -
  $E_{Miss} > 400\ MeV$,$E^*_{Miss} > 500\ MeV$

Signal Side Selection:

- Identified Muon ($P_\mu > 1.0\ GeV/c$)
- $N_\gamma = 1$ ($E_\gamma > 500\ MeV$,$E^*_\gamma > 400\ MeV$ and
- $0.5 < Cos\Theta^*_{\mu\gamma} < 0.75$

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Tau02: $\tau \longrightarrow \mu\gamma$ Cont.

Tag Side Selection:

- Single Charged - NOT a Muon,
- $Cos\Theta^{*}_{Tag/Miss} > 0.4$ and
- $E^{*}_{Tag} < 4.23\ GeV$

Results:

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Tau02: Neutrinoless τ Decays - 2

$\tau \rightarrow e/\mu + \geq 1K_s^0$

Current 90% CL Upper Limits

Expt.	Mark II	Belle (01)	Belle (02)
Luminosity	17 pb^{-1}	23.6 fb^{-1}	48.6 fb^{-1}
eK_s^0	6.5 $\times 10^{-4}$	9.0 $\times 10^{-7}$	2.9 $\times 10^{-7}$
μK_s^0	5.0 $\times 10^{-4}$	9.0 $\times 10^{-7}$	2.7 $\times 10^{-7}$

CLEO search with 13.9 fb^{-1} - K.K.Gan (Ohio)

Event Selection:

- 4 or 6 charged tracks - $Q^{Tot} = 0$
- $\mid Cos\Theta_{track} \mid < 0.90$
- $\mid Cos\Theta_{missing} \mid < 0.90$
- $E_{total} < 0.95 \times E_{CM}$

Tag Side:

- 1 charged track
- missing ν_τ in same hemi:
  $0.0 < Cos\Theta_{tag-missing} < 0.99$

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Tau02: $\tau \to e/\mu + \geq 1 K_s^0$ Cont.

Signal Side:

3 or 5 charged tracks with

- 1 identified e/μ - rest NOT
- 1 or 2 Pairs making a K_s^0 with $485 < M_{\pi\pi} < 510 MeV$ (3σ)

Results:

Elliptical Signal and Side boxes in ΔE $vs.$ ΔM

BELLE search in 48.6 fb^{-1} - 4.42×10^7 τ pairs

Expt.	CLEO - 13.9 fb^{-1}		Belle - 48.6 fb^{-1}	
Mode	ε(%)	UL (10^{-7})	ε(%)	UL (10^{-7})
eK_s^0	19.4 $\pm$ 0.4	9.1	13.8 $\pm$ 0.7	2.9
μK_s^0	19.0 $\pm$ 0.4	9.5	15.0 $\pm$ 0.7	2.7
$eK_s^0 K_s^0$	12.1 $\pm$ 0.1	22.0	-	-
$\mu K_s^0 K_s^0$	8.0 $\pm$ 0.1	34.0	-	-

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Tau02: Neutrinoless τ Decays - 3

$\underline{\tau \rightarrow 3 \ Leptons}$

BELLE search in 48.6 fb^{-1}

$e^+e^- \rightarrow \tau\tau$

- 4 charged tracks (Signal: $\tau \rightarrow 3$ & Tag: $\tau \rightarrow 1$)
- $Q_{total} = 0$
- 3-prong vs. 1-prong in C.o.M.

Signal side - Particle Identification:

- Electrons: $\varepsilon = 85\%$, hadron fake rate(η) $= 0.2\%$
- Muons: $\varepsilon, \eta = 80.0, 2.0$

Signal in ΔE^* vs. ΔM in 6 3-Lepton Final states

$e^-e^+e^-$, $\mu^-\mu^+\mu^-$, $e^-\mu^+\mu^-$, $\mu^-e^+e^-$, $e^+\mu^-\mu^-$ and $\mu^+e^+e^-$

Efficiencies: $\approx 10.0 \pm 0.5$ %