RARE TAU DECAYS

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ABSTRACT

The possibilities and challenges for studying rare decays of the τ with the large data samples from a tau-charm factory are discussed. These studies involve expected decays of the τ like multihadronic channels, suppressed decays like 2nd class currents or Cabibbo suppression, and possible unexpected decays.

1. INTRODUCTION

Present measurements in τ-decay are at the 10^{-2} level. Most branching ratios are known at that level and tests of couplings, etc. are at the few percent level. But, even at this level, the problem of the missing 1-prongs remains unresolved. This discrepancy could be experimental or could be physics and it appears that it will take better experiments to resolve.

Limits on rare-decays are typically at the $\sim 10^{-2}$ to 10^{-4} level. But, there have been difficulties doing the physics even at that level as can be seen in the experiments relating to 2nd class currents.

The challenges for doing rare τ-decays are several. First, a source of τ's prolific enough must be built. Candidates for such a machine include a tau-charm factory or a B-factory. The second problem is to obtain clean samples of tau leptons. A tau charm factory provides a nice answer to this, since it is possible to run below charm threshold. The remaining backgrounds from ordinary hadronic production can be studied by running below tau threshold. Finally, the detector must be powerful enough to reconstruct clearly the various τ final states. This requires excellent π, K separation and good reconstruction of π° and η's. It may be easier to meet these final detector demands at a tau-charm factory than a B-factory because the particles must be identified and reconstructed over a considerably smaller kinematic range.

In this talk, I discuss the interest and possibilities in rare decays of the tau. I cover the expected decays into hadronic channels, the suppressed decays like 2nd class currents or Cabibbo suppression, and finally make some comments on the unexpected decays.

2. HADRONIC DECAY MODES

A completely new and exciting area to pursue for tau decays is represented in tau hadronic decays. In contrast to μ's and e's the τ can decay into hadrons. The theoretical framework for these decays is based on the well tested assumptions that the weak hadronic current has V-A structure.

The general form of heavy lepton decay into hadronic final states through the V-A interactions has been derived by Tsai[1]:

$$\Gamma(\tau^- \to hadrons + \nu_\tau) = \frac{G^2}{32\pi^2 m_\tau^3} \int_0^{m_\tau^2} dq^2$$
$$\times (m_\tau^2 - q^2)^2 \{[(m_\tau^2 + 2q^2)[v_1(q^2) + a_1(q^2)] + m_\tau^2 a_0(q^2)]cos^2\theta_c$$
$$+ m_\tau^2 + 2q^2)[v_1^s(q^2) + a_1^s(q^2)] + m_\tau^2[v_0^s(q^2) + a_0^s(q^2)]]sin^2\theta_c\} \quad (1)$$

where v and a are vector and axial spectral functions and θ_c is the Cabibbo angle. Each spectral function refers to final states having unique spin-parity and strangeness assignments.

Equation (1) shows explicitly that, in general, only final states with J=1 or J=0 are allowed. The J=1 states are associated with v_1, a_1, v_1^s, while J=0 states are described by a_o, v_o^s and a_o^s. The spin-parity and strangeness assignment associated with different spectral functions are shown in table 1 along with possible resulting final state hadron states.

There are several theoretical restrictions on these spectral functions. The states with $GP(-1)^J$ <0 can exist only through second class currents[2] and therefore should be small or non-existent. In addition, the conserved vector current hypothesis (CVC) requires v_0=0; while PCAC requires a_0=0 for $q^2 > m_\pi^2$. Thus, eq. (1) can be simplified to:

$$\Gamma(\tau^- \to hadrons + \nu_\tau) = \frac{G^2}{32\pi^2 m_\tau^3} \int_0^{m_\tau^2} dq^2 (m_\tau^2 - q^2)^2 (m_\tau^2 + 2q^2)$$
$$\times \{v_1(q^2) + a_1(q^2)]cos^2\theta_c + [v_1^s(q^2) + a_1^s(q^2)]sin^2\theta_c\} \quad (2)$$

Table 1
Hadronic decays of the τ lepton

Spectral functions	Spin-parity J^p	Strangeness S	Possible final states
v_1	1^-	0	$\rho(770)$,$\rho'(1600)$, $(2\pi)^-$,$(4\pi)^-$,(K^-K^0)
a_1, a_0	1^+,0^-	0	π^-, $A_1(1270)$,$(3\pi)^-$
v_1^s,v_0^s	1^-1^+	-1	$K^*(890)$,$(K\pi)^-$
a_1^s, a_0^s	1^+,0^-	-1	K^-,Q_1,(1280),$Q_2(1400)$,$(K\pi\pi)^-$

Equation (2) represents a precise formulation of the weak hadronic decays depending only on the unknown spectral functions, each of which isolates particular hadronic channels. In this matter, the τ is a unique laboratory for isolating and studying these weak hadronic interactions. Specific relationships and predictions for these spectral functions can be obtained using CVC, PCAC and certain assumptions about the symmetries, as is usual in the phenomenology of weak hadronic decays. At present, much of the data is qualitative, but as the data improves, rigorous tests and constraints on weak hadronic decays will be possible.

The first and probably soundest prediction comes from invoking CVC. The CVC theorem relates the vector part of the strangeness conserving charged weak current to the isovector part of the total cross section for e^+e^- annihilations into hadrons

$$v_1(q^2) = \frac{q^2\sigma_{I=1}(e^+e^- \to hadrons)}{4\pi\alpha^2} = \frac{\sigma_{I=1}(e^+e^- \to hadrons)}{\sigma_{pt}}, \quad (3)$$

where σ_{pt} is the point cross section

$$\sigma_{pt} = 4\pi\alpha^2/q^2 \,. \tag{4}$$

Therefore, CVC yields a definite prediction for the rate of tau decay into vector mesons (e.g., $\tau^- \to \rho^-(770)\nu_\tau, \tau^- \to \rho'^-(1600)\nu_\tau$, etc.) obtained from the isovector cross section for e^+e^-into hadrons. The main uncertainty in this CVC prediction comes from the uncertainty in the determination of the isovector part of the total e^+e^- cross section.

For the vector mesons, different polarization states have to be summed up and the final state particles have a non-zero width described by the Breit-Wigner factor. For the $\rho^-(770)$ final state, the vector spectral function

$$v_1(q^2) = 4\pi\ g_{\rho\gamma}^2\ m_\rho^2\ \delta(q^2 - m_\rho^2) = 2\pi\frac{f_\rho^2}{m_\rho^2}\ \delta(q^2 - m_\rho^2) \tag{5}$$

has to be determined over the range of q^2 corresponding to the Breit-Wigner shape of the ρ meson and, in general, there may be an additional form factor dependence of the $g_{\rho\gamma}$ (the vector current coupling to the ρ). This latter uncertainty can be removed [1] by invoking the conserved-vector-current hypothesis (CVC) which relates the isovector part of the e^+e^-annihilation into hadrons to the vector part of the charged weak current:

$$v_1(q^2) = \frac{q^2}{4\pi^2\alpha^2}\ \sigma_{I=1}(e^+e^- \to hadrons) = \frac{1}{3\pi}\ \frac{\sigma_{I=1}(e^+e^- \to hadrons)}{\sigma_{point}}\,, \tag{6}$$

where σ_{point}=$4\pi\alpha^2/3q^2$ is the cross section for the process $e^+e^- \to \mu^+\mu^-$. Thus, the general equation (1) can be reduced to:

$$\Gamma(\tau^- \to \nu_\tau\rho^-) = \frac{G^2 cos^2\theta_c}{96\pi^3 m_\tau^2}\int_0^{m_\tau^2}(m_\tau^2 - q^2)^2(m_\tau^2 + 2q^2)\frac{\sigma_{I=1}(e^+e^- \to hadrons)}{\sigma_{point}}\ dq^2\,, \tag{7}$$

or alternatively,

$$R_\rho = \frac{\Gamma(\tau^- \to \nu_\tau \rho^-)}{\Gamma(\tau^- \to \nu_\tau e^- \overline{\nu}_e)}$$
$$= \frac{3cos^2\theta_c}{2\pi\alpha^2 m_\tau^2} \int_0^{m_\tau^2} q^2(m_\tau^2 - q^2)^2(m_\tau^2 + 2q^2)\sigma_{1=1}(e^+e^- \to hadrons)dq^2 \tag{8}$$

The extraction of the isovector part of the e^+e^- annihilation cross section into two pions represents a phenomenological challenge, since the data [3] include effects violating the relation [4] (e.g., the $\rho-\omega$ interference). Gilman and Rhie [5] performed a fit to the experimental data for e^+e^- annihilation and determined that

$$Br(\tau^- \to \nu_\tau \rho^-) = 1.23\ Br(\tau^- \to \nu_\tau e^- \overline{\nu}_e) = 21.4 \pm 0.5\% \tag{9}$$

with an additional systematic error, due to the overall normalization uncertainty of the e^+e^- cross section. This result is in excellent agreement with the data and also with alternative calculation by Tsai [6] who, in a narrow width approximation, used experimental width of the $\rho^o \to e^+e^-$ to obtain

$$\Gamma(\tau^- \to \nu_\tau \rho^-) = \Gamma(\rho^0 \to e^+e^-)\frac{3}{2}\,\frac{G^2 cos^2\theta_c m_\rho m_\tau^3}{(4\pi\alpha)^2}\left(1 - \frac{m_\rho^2}{m_\tau^2}\right)^2 \left(1 + \frac{2m_\rho^2}{m_\tau^2}\right) \tag{10}$$

leading to

$$Br(\tau^- \to \nu_\tau \rho) = 21.2 \pm 0.6\%$$

The phenomenology for the four pion final state is entirely analogous to that for the tau decay into $\rho\nu_\tau$. Inasmuch as the decay proceeds through the vector current, one can again relate the decay rate to an integral over the cross section for the e^+e^- annihilation into four pions. There are, however, two possible final states in e^+e^- interactions, namely $\pi^+\pi^+\pi^-\pi^-$ and $\pi^+\pi^-\pi^0\pi^0$. Also, there are two channels in τ decay, namely $\nu_\tau\pi^-\pi^+\pi^-\pi^0$ and $\nu_\tau\pi^-\pi^0\pi^0\pi^0$. Isospin constraints introduce linear relations between the corresponding rates, which result in the predictions analogous to eq. [8]:

$$R_{\pi^-\pi^+\pi^-\pi^0} = \Gamma(\tau^- \to \nu_\tau\pi^-\pi^-\pi^+\pi^0)/\Gamma(\tau^- \to \nu_\tau e^-\overline{\nu}_e)$$
$$= \frac{3}{2\pi\alpha^2 m_\tau^8}\int_0^{m_\tau^2} dq^2 q^2(m_\tau^2 - q^2)^2(m_\tau^2 + 2q^2)[\frac{1}{2}\sigma_{e^+e^-\to\pi^+\pi^+\pi^-\pi^-}(q^2)$$
$$+\sigma_{e^+e^-\to\pi^+\pi^-\pi^0\pi^0}(q^2)] \tag{11}$$

and a contribution to a 1-prong topology

$$R_{\pi^-\pi^0\pi^0\pi^0} = \Gamma(\tau^- \to \nu_\tau\pi^-\pi^0\pi^0\pi^0)/\Gamma(\tau^- \to \nu_\tau e^-\overline{\nu}_e)$$
$$= \frac{3}{2\pi\alpha^2 m_\tau^8}\int_0^{m_\tau^2} dq^2 q^2(m_\tau^2 - q^2)^2(m_\tau^2 + 2q^2)[\frac{1}{2}\sigma_{e^+e^-\to\pi^+\pi^+\pi^-\pi^-}(q^2)] \tag{12}$$

Numerical integration over the experimental data for e^+e^- annihilations leads [7] to

$$R_{\pi^-\pi^+\pi^-\pi^0} = 0.275 \tag{13}$$

and

$$R_{\pi^-\pi^0\pi^0\pi^0} = 0.055\,, \tag{14}$$

and the corresponding branching fractions are predicted to be: Br($\tau^- \to \nu_\tau\pi^-\pi^-\pi^+\pi^0$)=4.8±0.2% and Br($\tau^- \to \nu_\tau\pi^-\pi^0\pi^0\pi^0$) =0.96±0.03%. Although these values seem to be in good agreement with the data, the confrontation with the experimental results encounters two potential problems. On the one hand, the experiments usually have a difficulty in separating tau decays with one neutral pion from those with two or more π^0's in the final state and some groups neglect this latter possibility. On the other hand, the phenomenological prediction is based on the assumption that weak vector current mediates the tau decay. Such a process is expected to be dominated by the $\rho'(1600)$ production for which the decay into $\omega\pi^-$ is not known.

3. SUPPRESSED DECAYS

A. Cabibbo Suppressed

The general form of the hadronic decay width has been given in eq. (1). for any single particle final state this equation reduces to the term containing the corresponding spectral function only and the spectral function is then described by the matrix element of the corresponding weak current between the vacuum state and given particle final state [1].

Thus, for the decay

$$\tau^- \rightarrow \pi^- \nu_\tau \tag{15}$$

the corresponding spectral function is

$$\alpha_0(q^2) = 2\pi f_\pi^2 \; \delta(q^2 - m_\pi^2) \tag{16}$$

and eq. (1) reduces to:

$$\Gamma(\tau^- \rightarrow \pi^- \nu_\tau) = \frac{G^2 \; f_\pi^2 \; cos^2\theta_c \; m_\tau^3}{16\pi}\left[1 - \frac{m_\pi^2}{m_\tau^2}\right]^2 \; . \tag{17}$$

Unfortunately, the pion decay constant, f_π cos θ_c, measuring the strength of the pion coupling of the axial-vector current cannot be derived from the theory. The phenomenology of this process relies, therefore, on the fact that the same quantity is well measured in pion decay $\pi^- \rightarrow \mu^- \overline{\nu}_\mu$) as illustrated in fig. 1.

The rate of this process is given by

$$\Gamma(\pi^- \rightarrow \mu^- \overline{\nu}_\mu) = \frac{G^2 f_\pi^2 cos^2\theta_c}{8\pi} \; m_\pi m_\mu^2 \left[1 - \frac{m_\mu^2}{m_\pi^2}\right]^2 , \tag{18}$$

and the relation between the two decay rates is

$$\Gamma(\tau^- \rightarrow \pi^- \nu_\tau) = \frac{m_\tau^3(1 - m_\pi^2/m_\tau^2)^2}{2m_\pi m_\mu^2(1 - m_\mu^2/m_\pi^2)^2} \; \Gamma(\pi^- \rightarrow \mu^- \overline{\nu}_\mu) \, . \tag{19}$$

Thus, the experimentally measured branching fraction (the ratio of the partial decay rate to the total

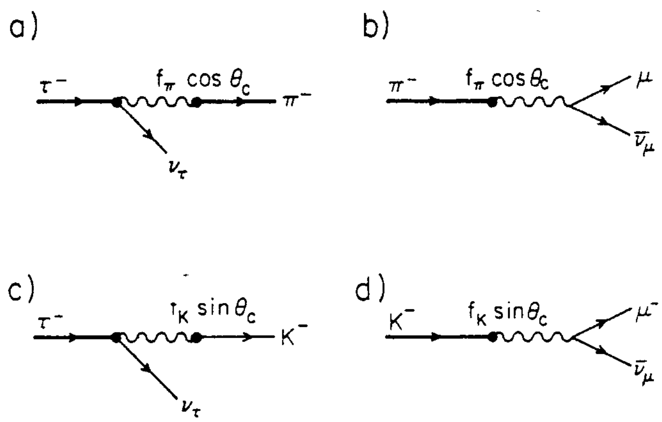

Fig. (1) Feynman diagrams for the decays a) $\tau \to \nu_\tau \pi$, b) $\pi \to \overline{\nu}_\mu \mu$, c) $\tau \to \nu_\tau$,K and d) K$\to \overline{\nu}_\mu \mu$.

rate) is given by the pion and tau lifetimes:

$$Br(\tau^- \to \pi^- \nu_\tau) = \frac{\Gamma(\tau^- \to \pi^- \nu_\tau)}{\Gamma_{tot}} = \frac{\tau^\tau}{\hbar}\,\Gamma(\tau^- \to \pi^- \nu_\tau)$$

$$= \frac{m_\tau^3(1 - m_\pi^2/m_\tau^2)^2}{2m_\pi m_\mu^2(1 - m_\mu^2/m_\pi^2)^2}\frac{\tau_\tau}{\tau_\pi} Br(\pi^- \to \mu^- \overline{\nu}_\mu) \tag{20}$$

The predicted branching fraction Br($\tau^- \to \pi^- \nu_\tau$)=10.9±0.5% is in excellent agreement with experimental measurements. The error on the expected value is completely dominated by the τ-lifetime measurement error of 4.5%.

An alternative method used by many authors [8] consists of calculating the ratio of the tau decay rate into the pion to the tau decay rate into the electron. The corresponding formula relies on the well-measured quantities only and does not depend on the tau lifetime

$$R_\pi = \frac{\Gamma(\tau^- \to \nu_\tau \pi^-)}{\Gamma(\tau^- \to \nu_\tau e^- \overline{\nu}_e} = \frac{96\pi^3}{m_\tau^2 m_\pi m_\mu^2}\,\frac{(1 - m_\pi^2/m_\tau^2)^2}{(1 - m_\mu^2/m_\pi^2)^2}\,\frac{\hbar}{G^2\tau_\pi} = 0.607\,, \tag{21}$$

and the branching fraction can be predicted using the electronic branching which is known at present time with better precision

$$Br(\tau^- \to \nu_\tau \pi^-) = 0.607\ Br(\tau^- \to e^- \nu_\tau \overline{\nu}_e) = 10.6 \pm 0.3\% \,. \qquad (22)$$

Here, the error is dominated by the uncertainty of the branching fraction for the tau decay into the electron. The error on the R_π value is negligibly small. This prediction is also in excellent agreement with results.

The situation is entirely analogous in the case of the tau decay into kaon and neutrino. Here, the corresponding spectral function is

$$a_0^2(q^2) = 2\pi f_K^2 \delta(q^2 - m_K^2) \,, \qquad (23)$$

where, again, the strength of the axial-vector current coupling to the kaon, $f_K \sin\theta_c$, is measured in the decay $K^- \to \mu^- \overline{\nu}_\mu$ as illustrated in fig. 1.

Following the procedure described above, we can calculate the corresponding branching fraction using the tau and kaon lifetime measurements:

$$Br(\tau^- \to \nu_\tau K^-) = \frac{m_\tau^3 (1 - m_K^2/m_\tau^2)^2}{2 m_K m_\mu^2 (1 - m_\mu^2/m_K^2)^2} \frac{\tau_\tau}{\tau_K}\ Br(K^- \to \mu^- \overline{\nu}_\mu) = 0.71 \pm 0.03\% \,, \qquad (24)$$

or from the ratio of the decay rate into kaon to the decay rate into electron

$$R_K = \frac{\Gamma(\tau^- \to \nu_\tau K^-)}{\Gamma(\tau^- \to \nu_\tau e^- \overline{\nu}_e)} = 0.0395 \,, \qquad (25)$$

we obtain the expectation value of $\mathrm{Br}(\tau^- \to \nu_\tau K^-) = 0.69 \pm 0.02\%$. Again, the two predictions agree very well with the data and with each other.

Finally, it is interesting to note that the decay rate into the kaon is related to the decay rate into the pion via the Cabibbo angle θ_c

$$\Gamma(\tau^- \to \nu_\tau K^-) = \Gamma(\tau^- \to \nu_\tau \pi) tan^2\theta_c \left[\frac{m_\tau^2 - m_K^2}{m_\tau^2 - m_\pi^2}\right]^2 . \qquad (26)$$

Thus, for $\tan^2\theta_c = 0.05$, the expected branching ratio is $\mathrm{Br}(\tau^- \to \nu_\tau K^-) = 0.44 \pm 0.14\%$, where the error is dominated by the uncertainty in the estimate of the Cabibbo angle [9].

The multiparticle decay modes including kaons in the final state come from both vector and axial-vector current processes.

The Cabibbo-allowed final state of $K\overline{K}\pi$ can come from the $\rho'(1600)$ decays into $K^*\overline{K}$ or $\overline{K^*}K$. In addition, isotopic spin conservation requires the ratio of the rates for different charge combinations to be

$$0 \leq K^+K^-\pi^-/all\ (KK\pi)^- \leq \frac{3}{4}. \qquad (27)$$

If the entire branching fraction of $\tau^- \to \nu_\tau\pi^-\pi^-\pi^+\pi^0$ is ascribed to the $\rho'(1600)$ intermediate state, the expected branching fraction Br($\tau^- \to \nu_\tau K^-K^+\pi^-$)=0.6% is consistent but somewhat larger than the DELCO measurement [108]. On the other hand, after subtraction of the observed $\omega\pi^-$ final state, which does not occur via the $\rho'(1600)$, the expected value of Br($\rho^- \to \nu_\tau K^+K^-\pi^-$) $\leq$0.4% is in good agreement with the data. The pure CVC prediction of 0.24% is compatible with the latter value.

The Cabibbo-suppressed mode $\tau^- \to \nu_\tau K^-\pi^+\pi^-$ is analogous to the $\tau^- \to \nu_\tau\pi^+\pi^-\pi^+$ case and is expected to proceed via the Q resonances. Here, the same uncertanty occurs as in the A_1 case when using the Das-Mathur-Okubo sum rules to relate this mode to the $\tau^- \to \nu_\tau\rho^-$ decay:

$$\Gamma(\tau^- \to \nu_\tau Q^-) = \Gamma(\tau^- \to \nu_\tau\rho^-)tan^2\theta_c\,\frac{m_{K^*}^2}{m_Q^2}\,\frac{\phi_Q}{\phi_\rho}, \qquad (28)$$

where ϕ_Q and ϕ_ρ are the phase space factors for the corresponding decay.

The uncertainty is further complicated by the existence of two Q resonances with different masses $Q_1(1280)$ and $Q_2(1400)$. This leads to expectation values for the Br($\tau^- \to \nu_\tau K^-\pi^+\pi^-$) = 0.11% to 0.33%, compatible with the data.

B. Decays through 2nd Class Currents

An example of a channel that involves 2nd class currents is $\tau^- \to \pi^- + \eta + \nu_\tau$. The estimated rate for this mode is

$$B(\tau^- \to \pi^- \eta \nu_\tau) = \left(\frac{\Delta m}{M}\right)^2 \times (\text{1st Class Current})$$

$$\Delta m = (m_d - m_u)$$
$$M = \text{Constituent quark mass}$$

$$B(\tau^- \to \pi^- \eta \nu_\tau) \approx 10^{-4}\ B(\tau^- \to \pi^- \nu)$$

(actually, estimates vary from (10^{-3}- 10^{-5})$\times$ B), so, the estimate is

$$B_{\pi^- \eta \nu T} \approx 10^{-4} - 10^{-6}\,.$$

The existing data, first had evidence for this reaction, which was not confirmed.

HRS	$5.1 \pm 1.0 \pm 1.2\ \ 10^{-2}$
present limits	$< 0.2\ \ 10^{-2}$

So, now there is no evidence for this reaction and a large data sample ($\sim\ 10^6$) tagged τ's would be necessary for a sensitive search. In addition, good reconstruction of η's is necessary. This subject is a good candidate for study with a tau-charm factory.

4. UNEXPECTED DECAYS

The first class of unexpected decays to search for with the large data samples from a charm-tau factory are those predicted from theory.

There are several possible effects of Higgs Bosons that could be observed with tau's. Studies of the parameter ξ in the decay $\tau \to \mu\nu\overline{\nu}$ is sensitive. Another test is the Universality of the τ - μ - e. Finally, an attractive mode to see the effects of the Higgs in the rare decay mode involving lepton flavor violation. Due to the stronger Higgs coupling to taus, there is a large enhancement in such a mode -

$$eg.\ \frac{BR(\tau \to \mu\mu\mu)}{BR(\mu \to eee)} \simeq \left(\frac{m_\tau}{m_e}\right)^2 \approx 10^7$$

Such an enhancement implies that studying this mode with sensitivity of $\sim 10^{-6}$ is competitve with rare K-decay or other possible modes.

Other possible rare decays include channels like $\tau \rightarrow e + \gamma$ that could exist through supersymmetric diagrams. Leptoquarks could be observed through $\tau \rightarrow \mu\pi$, which has no kinematic suppression like the analogous D$\rightarrow \mu^+e^-$ channel. Finally, channels like $\tau \rightarrow \mu\phi$ have a large enhancement in models of compositeness and technicolor.

Lastly, new physics might well appear by investigating more generic searches for forbidden channels.

Examples, Lepton Conservation tests -

present

$$\gamma's \begin{cases} \Gamma(\mu^-\gamma) & <5.5\ \ 10^{-4} \\ \Gamma(e^-\gamma) & <6.4\ \ 10^{-4} \end{cases}$$

$$Leptons \begin{cases} \Gamma(\mu^-\mu^-\mu^+) & <2.9\ \ 10^{-5} \\ \Gamma(e^-\mu^+\mu^-) & <3.3\ \ 10^{-5} \\ \Gamma(\mu^-e^+e^-) & <3.3\ \ 10^{-5} \end{cases}$$

$$Hadrons \begin{cases} \Gamma(\mu^-\pi^\circ) & <8.2\ \ 10^{-4} \\ \Gamma(e^-\pi^\circ) & <2.1\ \ 10^{-3} \\ \Gamma(\mu^-K^\circ) & 1.0\ \ 10^{-3} \end{cases}$$

Even, "crazy" searches could be worth investigating like, for example,

$$\tau \rightarrow p + ...$$

which violates both Baryon number and Lepton number, but conserves (B-L).

CONCLUSIONS

The rare decay modes of the τ are a very promising area to pursue at a tau-charm factory. There is rich physics to pursue in the allowed channels - particularly the multihadronic modes. These will require large data samples, clean tagging, good K/π separation and $\pi^\circ(\eta^\circ)$ reconstruction.

The suppressed modes of the tau are accessable. They include the Cabibbo suppressed modes and the search for 2nd class currents.

Finally, forbidden modes can provide sensitive tests of new physics, often with large enhancement factors. These might be some of the most sensitive ways to see the effect of the Higgs.

Rare tau decays are indeed a rich area that could be addressed on the proposed tau-charm factory.

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