TAU RADIATIVE DECAYS AT THRESHOLD

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A. Radiative leptonic decays:

$$\tau \rightarrow \mu + \nu_\mu + \nu_\tau + \gamma \qquad (1)$$

$$\tau \rightarrow e + \nu_e + \nu_\tau + \gamma \qquad (2)$$

Stahl and Voss, Zeit. Phys. C 74, 73 (1997), have shown that the kinematics of the radiative leptonic decay can be used to study some Michel parameters, that are otherwise difficult to measure.

Look for the so-called radiation zeros, a kinematic region where there would be zero radiation in lowest order if the anomalous magnetic moment of the tau were zero. Since the Schwinger anomalous magnetic moment, described by $a = (g-2)/2 = \alpha/(2\pi) + \ldots$ is not zero, a sufficiently precise measurement would measure the Schwinger anomalous magnetic moment. See M. L. Laursen et al., Phys. Rev. D 29, 2652 (1984). Both of these studies are difficult to very difficult.

Radiative semileptonic decays such as:

$$\tau \rightarrow \pi + \nu_\tau + \gamma \qquad (3)$$

$$\tau \rightarrow \rho + \nu_\tau + \gamma \qquad (4)$$

allow one to study the W-hadron-γ vertex, obtaining form factors.

B. PRESENT STUDIES AND THEIR PROBLEMS.

The best published study of tau radiative decay is of

$$\tau \rightarrow \mu + \nu_\mu + \nu_\tau + \gamma \qquad (5)$$

by G. Alexander et al. Phys. Lett. B 388, 437 (1996).

At CLEO, my colleague Xiaofan Zhou and I are studying

$$\tau \rightarrow \mu + \nu_\mu + \nu_\tau + \gamma$$

$$\tau \rightarrow e + \nu_e + \nu_\tau + \gamma$$

There are three problems that have made it difficult to carry out these studies with precision at LEP and CESR:

(a) A γ produced in the tau pair production process

$$e + e \rightarrow \tau + \tau + \gamma$$

cannot be directly distinguished from the γ produced in the radiative decays, Eqs 1-4.

(b) There is no a priori way to tell if a radiated γ came from one τ decay or from the other τ decay.

(c) If on the τ's decays semileptonic, an hadronic split-off may be mistaken for a γ.

C. PROBLEMS (a) AND (b) CAN BE SOLVED BY MEASURING RADIATIVE DECAYS AT THE TAU PAIR THRESHOLD

Consider studying radiative muonic decay with a pion decay as the tag at say 10 MeV above threshold.

$$e + e \rightarrow \tau 1 + \tau 2 + \gamma 0 \qquad (6)$$

$$\tau 1 \rightarrow \mu + \nu_{\mu} + \nu_{\tau} + \gamma 1 \qquad (7)$$

$$\tau 2 \rightarrow \pi + \nu_{\tau} \qquad (8)$$

Then the energy of $\gamma 0$ must be smaller than 10MeV, and that is acceptable because for new physics studies one is primarily interested in higher energy gamma's. This solves problem (a)

Also note that the process in Eqs. 6-8 cannot in general be confused by radiative pionic decay:

$$e + e \rightarrow \tau 1 + \tau 2 + \gamma 0 \qquad (9)$$

$$\tau 1 \rightarrow \mu + \nu_{\mu} + \nu_{\tau} \qquad (10)$$

$$\tau 2 \rightarrow \pi + \nu_{\tau} + \gamma 2 \qquad (11)$$

because the allowed energy range of $\gamma 2$ is set by the measured energy of the pion. This solves problem (b). Of course the precision of this and the previous statement depends upon the precision of kinematic measurements and the beam energy spread.

D. THE HADRONIC SPLIT-OFF PROBLEM

Problem(c) will still be with us. The hadronic split-off problem is discussed by M. Suffert in the proceedings of the Third Workshop on the Tau-Charm Factory, page 678. Of course this problem is also present at the B-factories. J. Swain will discuss what might be done.

E. OTHER TAU DECAY STUDIES AT THRESHOLD

Are there other tau decay studies that will benefit from the use of the energy threshold to reduce contamination or decay mode misidentification?