Model Independent Analysis
of
Lepton Flavor Violating
$\tau^{\pm} \rightarrow \mu^{\pm}\mu^{\pm}\mu^{\mp}$ Decays

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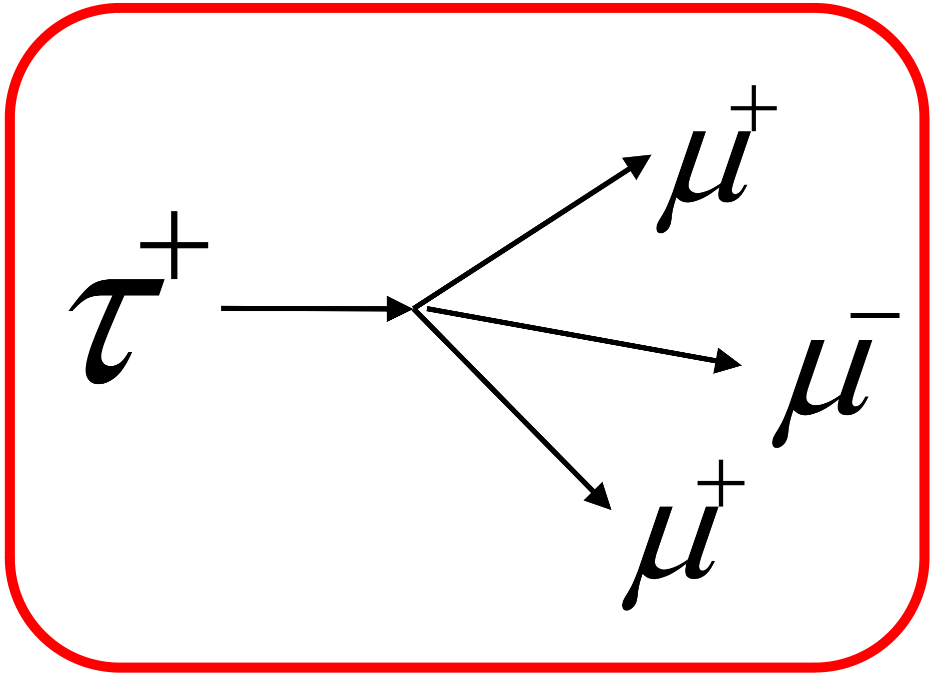


arXiv:0711.0792

Why is the LFV important?

- It has never seen.
- It is the null test.
- It gives the strict constraint.

Upper limit of $\tau \rightarrow \mu\gamma$ is 4.5×10^{-8} at 90% CL.
Belle Collaboration , **hep-ex/0609049**

- It contains the intermediate effect.

What is the model independent analysis?
~ $\tau \to 3\mu$ case ~

Usual analysis

1. Assuming the symmetry or the model
2. Calculating the differential branching ratio of $\tau \to 3\mu$ in that model
3. Prediction

From the symmetry or model, they predict the physical quantity.

Ours

1. Making the general Lagrangian without assumptions
2. Calculating the differential branching ratio of $\tau \to 3\mu$ from the Lagrangian
3. Fit the coupling parameters to the experimental result and determine the current structure.

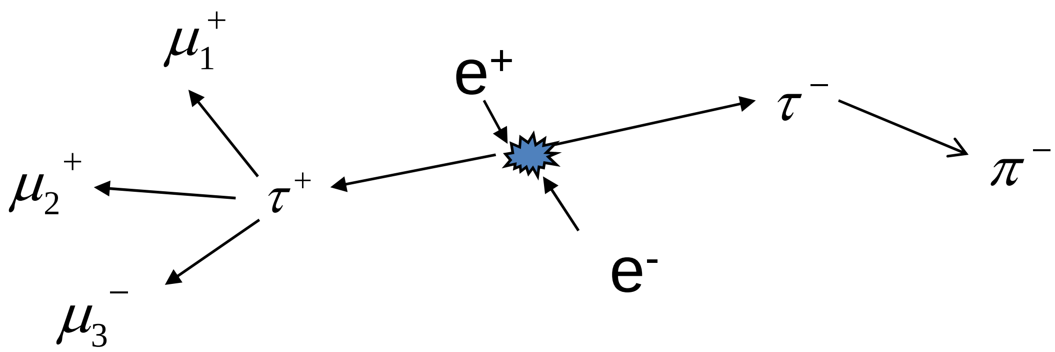
From the physical quantity given by the experiment, we revile the symmetry or theory like the Michel parameter.

$\tau \rightarrow 3\mu$ process in B-Factory.

- We derived that the differential crosssection from electron positron beam to 3μ + 1-prong event in the context of B-Factory.

$$
\begin{aligned}
&\frac{d\sigma}{d\Omega\ dx_1 dx_2 d\Omega_\tau d\psi\ d^3k_a} \\
&= \sum_{s^+,s^-} \sum_{\pm s^+,\pm s^-} \frac{d\sigma\left(e^+e^- \rightarrow \tau^+(s^+)\tau^-(s^-)\right)}{d\Omega} \\
&\quad \times \frac{dBr\left(\tau^-(s^-) \rightarrow \nu_\tau + a + \text{anything}\right)}{d^3k_a} \\
&\quad \times \frac{dBr\left(\tau^+(s^+) \rightarrow \mu_1\mu_2\mu_3\right)}{dx_1 dx_2 d\Omega_\tau d\psi}.
\end{aligned}
$$

- We consider τ polarization using the correlation between the tag side and the signal side τ decay products to know CP feature.



The general Lagrangian of τ→3μ is

$$\mathcal{L}_{FF} = -2\sqrt{2}G_F\Big\{ \quad g_1(\bar{\tau}_R\mu_L)(\bar{\mu}_R\mu_L) + g_2(\bar{\tau}_L\mu_R)(\bar{\mu}_L\mu_R)$$
$$+ g_3(\bar{\tau}_R\gamma_\alpha\mu_R)(\bar{\mu}_R\gamma^\alpha\mu_R) + g_4(\bar{\tau}_L\gamma_\alpha\mu_L)(\bar{\mu}_L\gamma^\alpha\mu_L)$$
$$+ g_5(\bar{\tau}_R\gamma_\alpha\mu_R)(\bar{\mu}_L\gamma^\alpha\mu_L) + g_6(\bar{\tau}_L\gamma_\alpha\mu_L)(\bar{\mu}_R\gamma^\alpha\mu_R)\Big\},$$

$$\mathcal{L}_\gamma = -\,2\sqrt{2}G_F m_\tau\Big\{A_R\bar{\tau}_R\sigma^{\alpha\beta}\mu_L F_{\alpha\beta} + A_L\bar{\tau}_L\sigma^{\alpha\beta}\mu_R F_{\alpha\beta}\Big\}$$
$$+ \bar{\mu}(iD^\alpha\gamma_\alpha - m_\mu)\mu - \frac{1}{4}F^{\alpha\beta}F_{\alpha\beta},$$

We set the parameters as

$$a_+ = (\frac{|g_1|^2}{16} + |g_3|^2) + (\frac{|g_2|^2}{16} + |g_4|^2)$$
$$b_+ = |g_5|^2 + |g_6|^2$$
$$c_+ = |eA_R|^2 + |eA_L|^2$$
$$d_+ = -\big(Re[g_3 e A_L^*] + Re[g_4 e A_R^*]\big)$$
$$e_+ = -\big(Re[g_6 e A_R^*] + Re[g_5 e A_L^*]\big).$$

We find the relation between parameters

$$a_+c_+ - d_+^2 \geq 0$$
$$b_+c_+ - e_+^2 \geq 0$$

We can take these parameters analyzing the energy distribution. parameters as

$$a_+ = (\frac{|g_1|^2}{16} + |g_3|^2) + (\frac{|g_2|^2}{16} + |g_4|^2)$$
$$b_+ = |g_5|^2 + |g_6|^2$$
$$c_+ = |eA_R|^2 + |eA_L|^2$$
$$d_+ = -(Re[g_3 eA_L^*] + Re[g_4 eA_R^*])$$
$$e_+ = -(Re[g_6 eA_R^*] + Re[g_5 eA_L^*]).$$

Using the relations

$$a_+ c_+ - d_+^2 \geq 0$$
$$b_+ c_+ - e_+^2 \geq 0$$

Even if

$$c_+ \gg d_+ \gg a_+$$

and we cannot detect a_+, directly,

we give the lower bounds of

$$a_+ \geq \frac{d_+^2}{c_+}$$
$$b_+ \geq \frac{e_+^2}{c_+}$$

Even if

$$a_+ \gg d_+ \gg c_+$$

and we cannot detect c_+, directly,

we give the lower bounds of

$$c_+ \geq \frac{d_+^2}{a_+}$$
$$c_+ \geq \frac{e_+^2}{b_+}$$

Using the angular distribution,

$$|eA_L|^2 \geq \frac{(d_+ + d_-)^2}{2(a_+ + a_-)}$$

We can determine the $|eA_L|$ lower bound.

$$\begin{aligned}
a_- &= (\frac{|g_1|^2}{16} + |g_3|^2) - (\frac{|g_2|^2}{16} + |g_4|^2) \\
b_- &= |g_5|^2 - |g_6|^2 \\
c_- &= |eA_R|^2 - |eA_L|^2 \\
d_- &= -(Re[g_3 eA_L^*] - Re[g_4 eA_R^*]) \\
e_- &= -(Re[g_6 eA_R^*] - Re[g_5 eA_L^*]), \\
f_+ &= -(Im[g_3 eA_L^*] + Im[g_4 eA_R^*]) \\
g_+ &= -(Im[g_6 eA_R^*] + Im[g_5 eA_L^*])
\end{aligned}$$

And, we can determine the imaginary part of the interference term.

$$Im[g_6 eA_R^*] = -\frac{b_+ c_- - b_- c_+ - 2e_+ e_- + 2g_+^2}{4g_+}$$

This is not the absolute value!

So, we can determine the argument without sign ambiguity.

$$Arg[g_6 eA_R^*]$$

Conclusions

- We analyze the lepton flavor violating $\tau \to 3\mu$ decay mode in model independent method.
- We analyze the angular distribution between signal side decay product and tag side one to know the CP feature.
- We reveal that we can determine the lower bounds of the interactions even if they are too small to detect directly, and we can determine the argument of interference terms without sign ambiguity.