MC study of the measurement of Michel parameters in the radiative leptonic decays of tau at Belle

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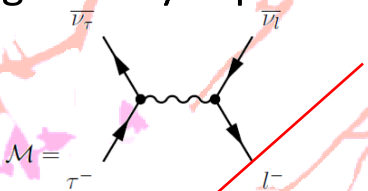
- Michel parameters (MP)
  - Assuming QFT and Lorenz invariance, amplitude of τ's leptonic decay are generally expressed as sum of S, V and T interactions with g_{ij}^{N} .

S : scalar
V : vector
T : tensor

$\mathcal{M} =$



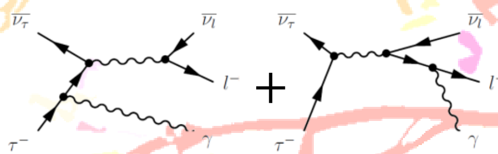
$$= \frac{4G_F}{\sqrt{2}} \sum_{\substack{N=S,V,T \\ i,j=L,R}} g_{ij}^{N} \left[\overline{u_i}(l^-)\Gamma^N v_n(\overline{\nu_l})\right]\left[\overline{u_m}(\nu_\tau)\Gamma_N u_j(\tau^-)\right]$$

good unbiased test of the SM, where only $g_{LL}^{V} = 1$ is nonzero

  - bilinear combinations of g_{ij}^{N} are experimentally observable →$\rho, \eta, \xi\delta, \xi, \bar{\eta}, \xi\kappa$
  - Measurement of $\rho, \eta, \xi\delta, \xi$ are already ongoing in ordinary leptonic decay $\tau \to l\bar{\nu}\nu$.
  - Of all MPs, $\bar{\eta}, \xi\kappa$ are measured only by radiative leptonic decay $\tau \to l\bar{\nu}\nu\gamma$
    - Small branching ratio : $\mathcal{B}_r(\tau \to e\bar{\nu}\nu\gamma) \sim 1.75\%$, $\mathcal{B}_r(\tau \to \mu\bar{\nu}\nu\gamma) \sim 0.36\%$, $E_\gamma > 10$ MeV (CLEO experiment)

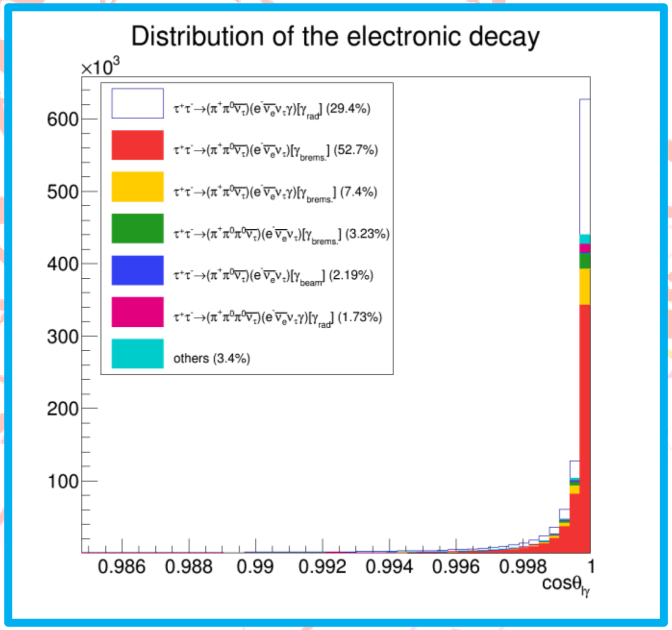
$$\bar{\eta} = |g_{RL}^{V}|^2 + |g_{LR}^{V}|^2 + \frac{1}{8}\left(|g_{RL}^{S} + 2g_{RL}^{T}|^2 + |g_{LR}^{S} + 2g_{LR}^{T}|^2\right) + 2\left(|g_{RL}^{T}|^2 + |g_{LR}^{T}|^2\right)$$

$$\xi\kappa = |g_{RL}^{V}|^2 - |g_{LR}^{V}|^2 + \frac{1}{8}\left(|g_{RL}^{S} + 2g_{RL}^{T}|^2 - |g_{LR}^{S} + 2g_{LR}^{T}|^2\right) + 2\left(|g_{RL}^{T}|^2 - |g_{LR}^{T}|^2\right)$$

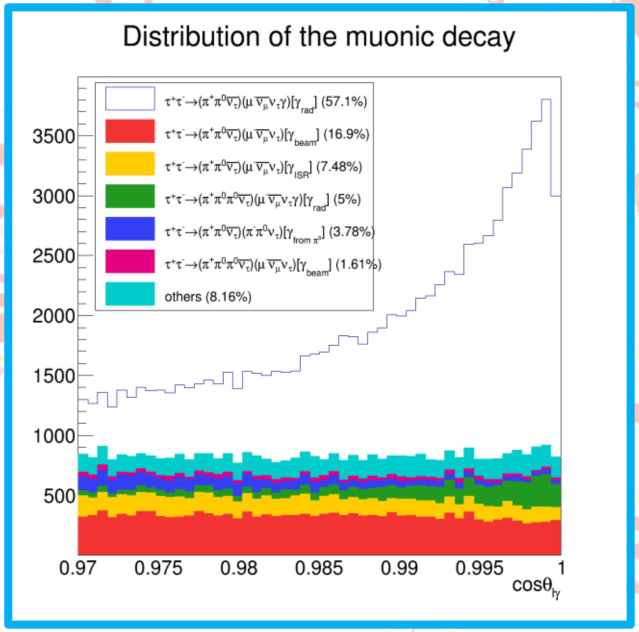


MP	ρ	η	$\xi\delta$	ξ	$\bar{\eta}$	$\xi\kappa$
SM	0.75	0	0.75	1	0	0
EX	0.747±0.010 ± 0.006 1.2%	0.012 ± 0.026 ± 0.004 2.6%	0.0745 ± 0.026 ± 0.009 2.8%	1.007±0.040 ± 0.015 4.3%	not measured yet	

In order to extract the Michel parameters $(\bar{\eta}, \xi\kappa)$, $(\tau, \tau) \to (\pi\pi^0, l\gamma)$ events are used.
Here $l = e, \mu$.
Background events for this mode was determined as follows:



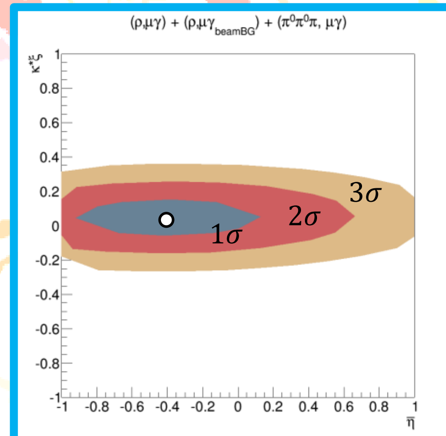
$(\tau, \tau) \to (\pi\pi^0, e\gamma)$



$(\tau, \tau) \to (\pi\pi^0, \mu\gamma)$

Electron mode:
major BG is "extra"-brems.

Muon mode:
1. beam BG
2. ISR γ + $(\pi\pi^0, l)$
3. $(\pi\pi^0\pi^0, l\gamma)$



Probability density function of events is calculated on the 12 dimension phase space and it is used to construct likelihood function.
Minimization of the likelihood function gives us the Michel parameters.

$$P(\vec{x}) = (1 - \sum_i \lambda_i) \cdot \frac{S(\vec{x})\varepsilon(\vec{x})}{\int d\vec{x} S(\vec{x})\varepsilon(\vec{x})} + \sum_i \lambda_i \frac{B_i(\vec{x})\varepsilon(\vec{x})}{\int d\vec{x} B_i(\vec{x})\varepsilon(\vec{x})} \Rightarrow \mathcal{L}(\bar{\eta}, \xi\kappa) = -\sum_{k=1}^{Nevents} \log P\left(\overrightarrow{x^{(k)}}\right)$$