Study of $\tau^- \to \pi^- \pi^0 \upsilon_\tau$ decay

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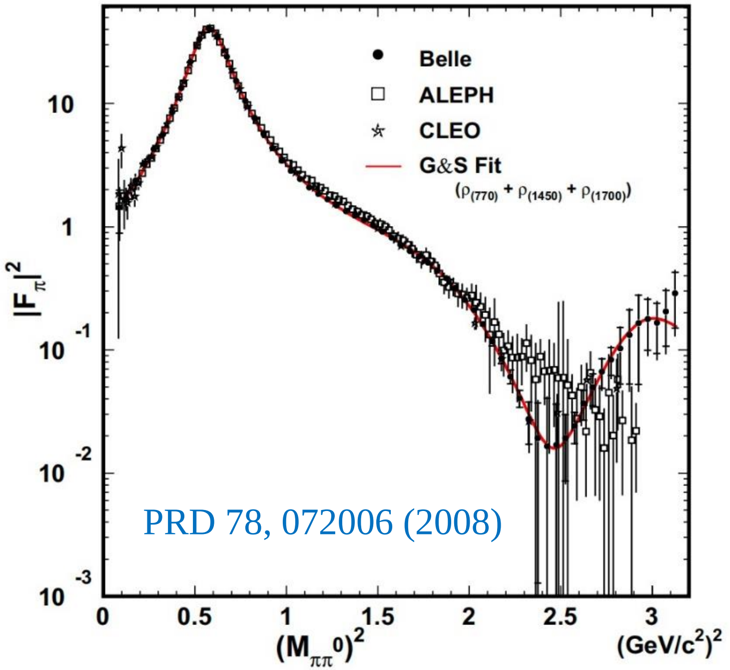
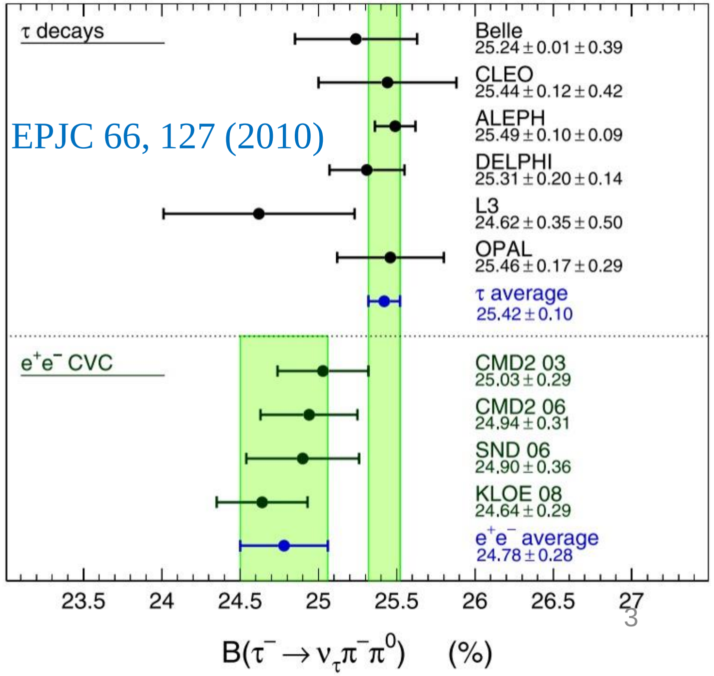
Outline

1. Motivation
2. Dataset
3. Event selection
4. Final distribution
5. Summary
6. Contribution

Motivation

- Measuring $\mathcal{B}(\tau^- \to \pi^- \pi^0 \upsilon_\tau)$ and spectral function of $M_{\pi^\pm\pi^0}$ can calculate the contribution to $a_\mu^{had,LO}$ of 2π system; It seems there is a systematic discrepancy between a_μ^τ and $a_\mu^{e^+e^-}$
- Determine the resonance parameters of ρ', ρ'' states
- Combination with $\tau^- \to (n\pi^-)(m\pi^0)\upsilon_\tau$ can calculate the value of a_s at m(τ)
- The main background to measure $\mathcal{B}(\tau^- \to K^- \pi^0 \upsilon_\tau)$, which is the main channel for Inclusively measuring V_{us} matrix element





Dataset

- **Signal MC sample**:

  DIY-MC(KKMC+Tauola): 1 million for τ^+ and τ^- each

  $\tau^{\pm} \rightarrow \text{inclusive}, \quad \tau^{\mp} \rightarrow \pi^{\mp}\pi^{0}(\gamma)\nu_{\tau}$ (Amp from Belle fitting)

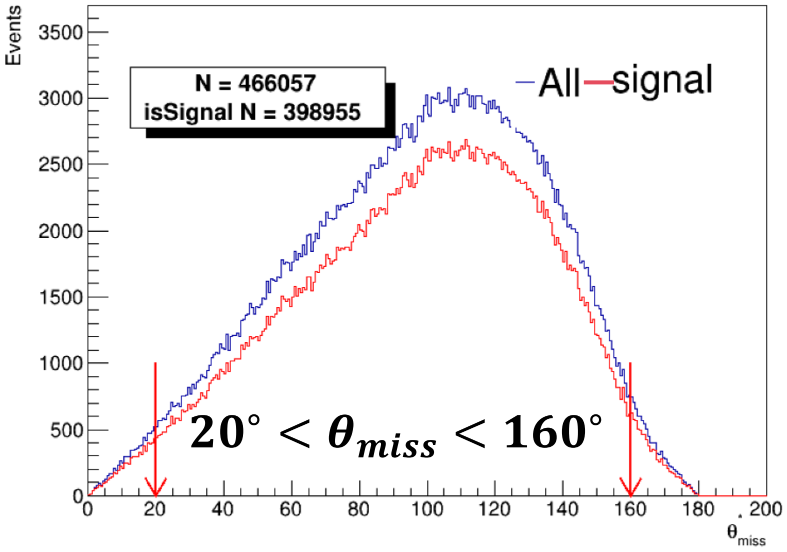
- **Generic MC sample**

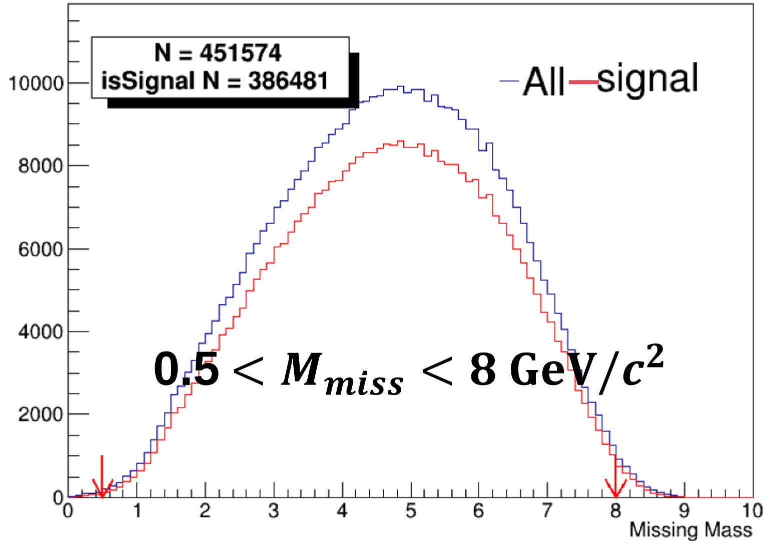
  1. Run-independent MC: 40$\pm$? fb^{-1}
  2. qqbar(uubar, ddbar, ssbar, ccbar), charged(B^+B^-), mixed($B^0\overline{B}^0$)

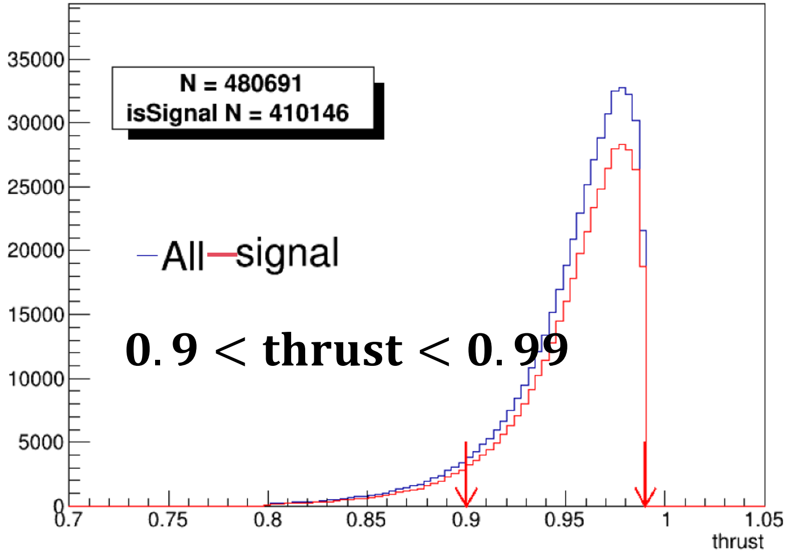
Event selection

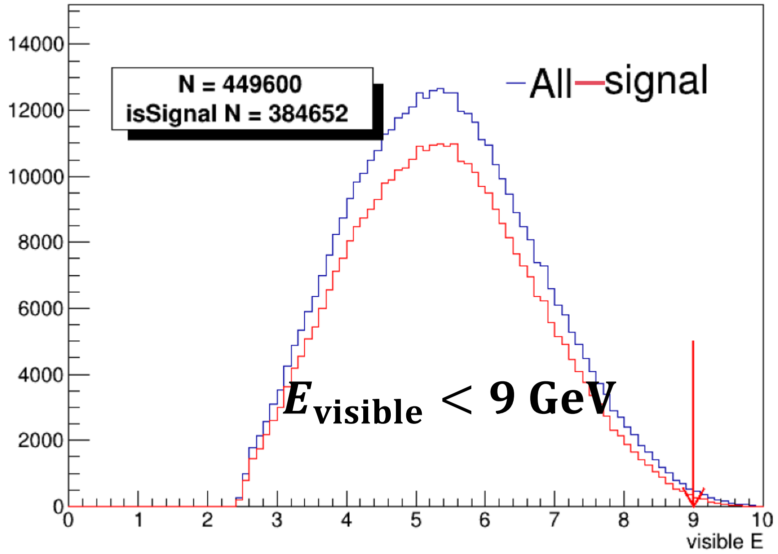
1. **Track level**: $|d_r| < 1$ cm, $|d_z| < 3$ cm, $p_T > 0.1\ \mathrm{GeV}/c$, $Q_{tot} = 0$, $N_{trk} = 2$
2. **τ revent**: $m(\tau)^{\text{tag/sig}}_{\text{candidate}} < 1.8$ GeV/ c^2, $\cos\theta^{\text{tag}}_{trust} \cdot \cos\theta^{\text{sig}}_{trust} < 0$
3. **PID**: $R_e^{\sout{SVD+TOP}} > 0.9$, $R_\mu^{\sout{SVD}} > 0.9$(for tag side), $R_\pi > 0.95$ & E/p < 0.8 (for signal side)
4. **π^0 selection**: pi0cutsTauOpt (0.115 < m($\gamma\gamma$) < 0.152 GeV/c^2 and 1C fit)
5. **Further requirements:**
    1. $N^{\text{tag}}_{\pi^0} \leq 1$, $E^{\text{tag}}_\gamma < 2$ GeV; $N^{sig}_{\pi^0} = 1$, $N^{sig}_{\gamma\notin\pi^0}$=0 to reduce π^0-related tau background
    2. (see next)

Further selection

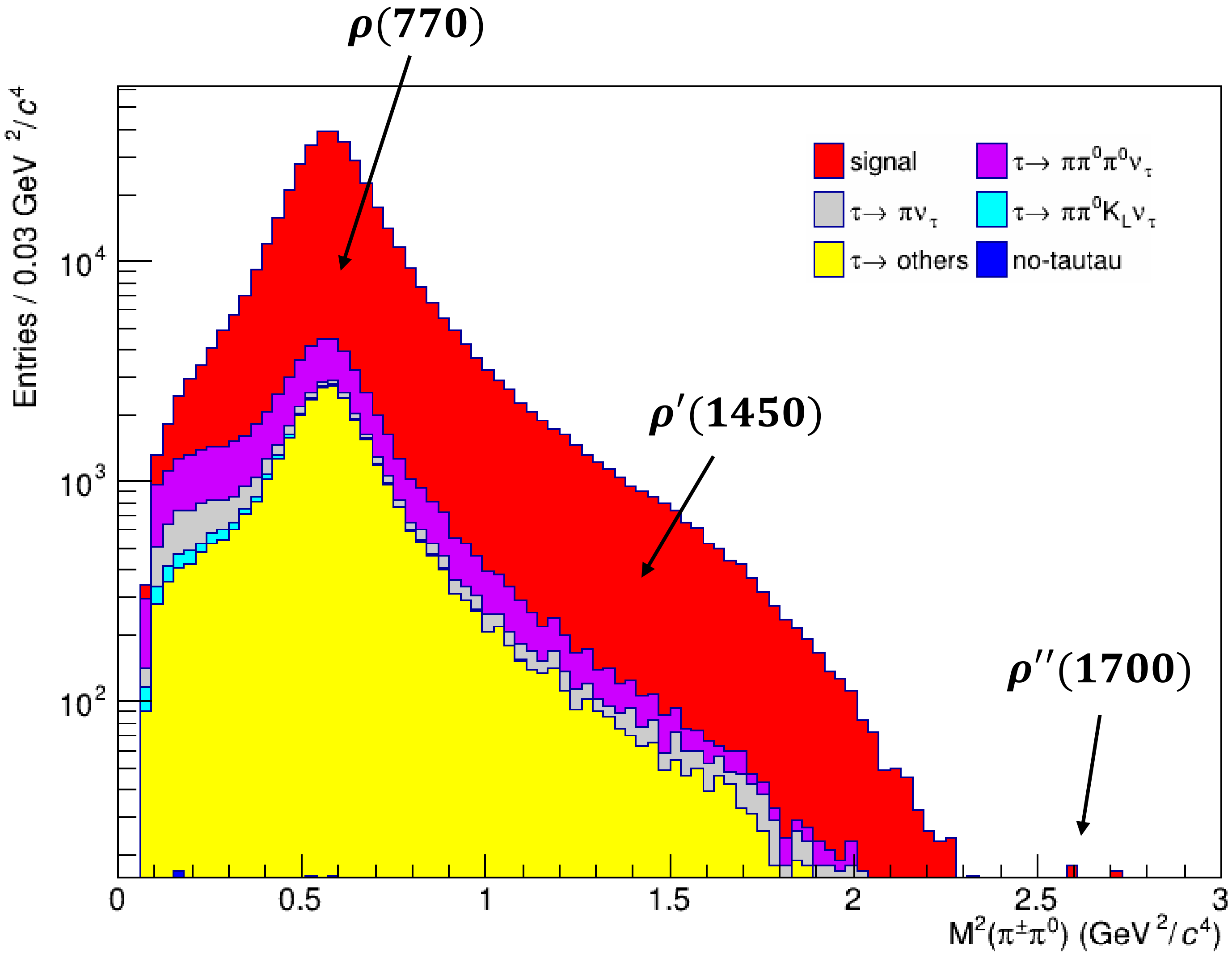






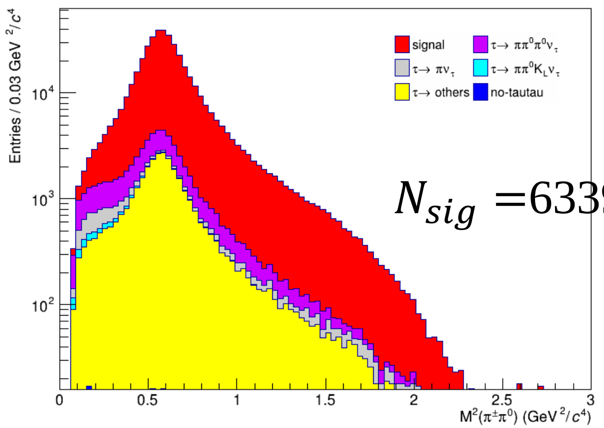


Final distribution



Background analysis

BG mode	events	
Total	15716	
1	58	
2	90	
3	137	
4	175	
110	845	$* \tau^- \to \pi^-\pi^0\gamma\nu_\tau$
111	10844	$\tau^- \to \pi^-\pi^0\pi^0\nu_\tau$
112	35	
116	166	
127	485	$\tau^- \to \pi^-\pi^0K_L^0\nu_\tau$
165	142	
226	210	
227	169	
303	2237	$\tau^- \to \pi^-\nu_\tau$



N_{sig} =63399

	ϵ	Signal purity
$\tau^+\tau^-$	$13.67 \pm 0.02\%$	98.7%
$\tau^- \to \pi^-\pi^0$	$30.84 \pm 0.09\%$	88.7%

1. The photons from the π^0 may merge into a single or be missed/misidentified as fake
2. The K_L^0 will not leave any information in the detector, so it is effectively equivalent to a neutrino.
3. Fake photons may be misidentified and combined to form a fake π^0.

* The process cannot be distinguished from the signal process in our work.

Branching faction from generic MC

$$B(\tau^- \to \pi^-\pi^0 v_\tau) = \frac{N^{sig}_{\pi^-\pi^0} \cdot p_{\tau^+\tau^-} \cdot p_{\pi^-\pi^0}}{\varepsilon_{\text{signal}}} \times \frac{1}{2 \cdot \mathcal{L} \cdot \sigma_{\tau^+\tau^-}} = (19.45 \pm 0.47_{\text{MC}})\%$$

Purity:

1. $\tau^+ \tau^-$ - 98.7%
2. $\tau^- \to \pi^-\pi^0 v_\tau$ - 88.7%

Efficiency:

1. $\tau^- \to \pi^-\pi^0 v_\tau$ - $4.24 \pm 0.02\%$

- Inclusive tag side, and $\tau^- \to \pi^-\pi^0 v_\tau$ as signal side
- Assume $\mathcal{L}$ = 40 fb^{-1}
- **Also test the signal MC sample with only electron as tag side. The BR result is $(26.38 \pm 0.27_{\text{MC}})\%$. So need further check of efficiency.**

TABLE III. Branching fractions for $\tau^- \to h^-\pi^0\nu_\tau$ measured by different experiments.

Experiment	$\mathcal{B}_{h\pi^0}(\%)$	Reference
CLEO	25.87 ± 0.12 ± 0.42	[21]
L3	25.05 ± 0.35 ± 0.50	[24]
OPAL	25.89 ± 0.17 ± 0.29	[23]
ALEPH	25.924 ± 0.097 ± 0.085	[19]
DELPHI	25.740 ± 0.201 ± 0.138	[25]
This work	25.67 ± 0.01 ± 0.39	

measurement [48] to obtain the result $\mathcal{B}_{K^-\pi^0} = (0.428 \pm 0.015)\%$. Subtracting this from our $\tau^- \to h^-\pi^0\nu_\tau$ result gives a $\tau^- \to \pi^-\pi^0\nu_\tau$ branching fraction of

$$\mathcal{B}_{\pi\pi^0} = (25.24 \pm 0.01 \pm 0.39)\%, \quad (10)$$

2008, Belle 72.2 fb^{-1}

Summary

1. Using $40\ \mathrm{fb}^{-1}$ generic MC samples, signal of $\tau^- \to \pi^-\pi^0\nu_\tau$ is selected.
2. Branching fraction $\mathcal{B}(\tau^- \to \pi^-\pi^0\nu_\tau)$ is calculated, but the efficiency is not so reliable. More checks are needed.

Contribution:

- Yijia Chen: MC sample generation
- Yiwei Huang: Drawing and event selection
- Yipu Liao: Analysis algorithm
- Wenjie Liu: Drawing and slide preparation